GOLETA WATERSHED COMPREHENSIVE
AND WATER CONSERVATION PLANNING P

GOLETA WATERSHED RE

JUNE 1968

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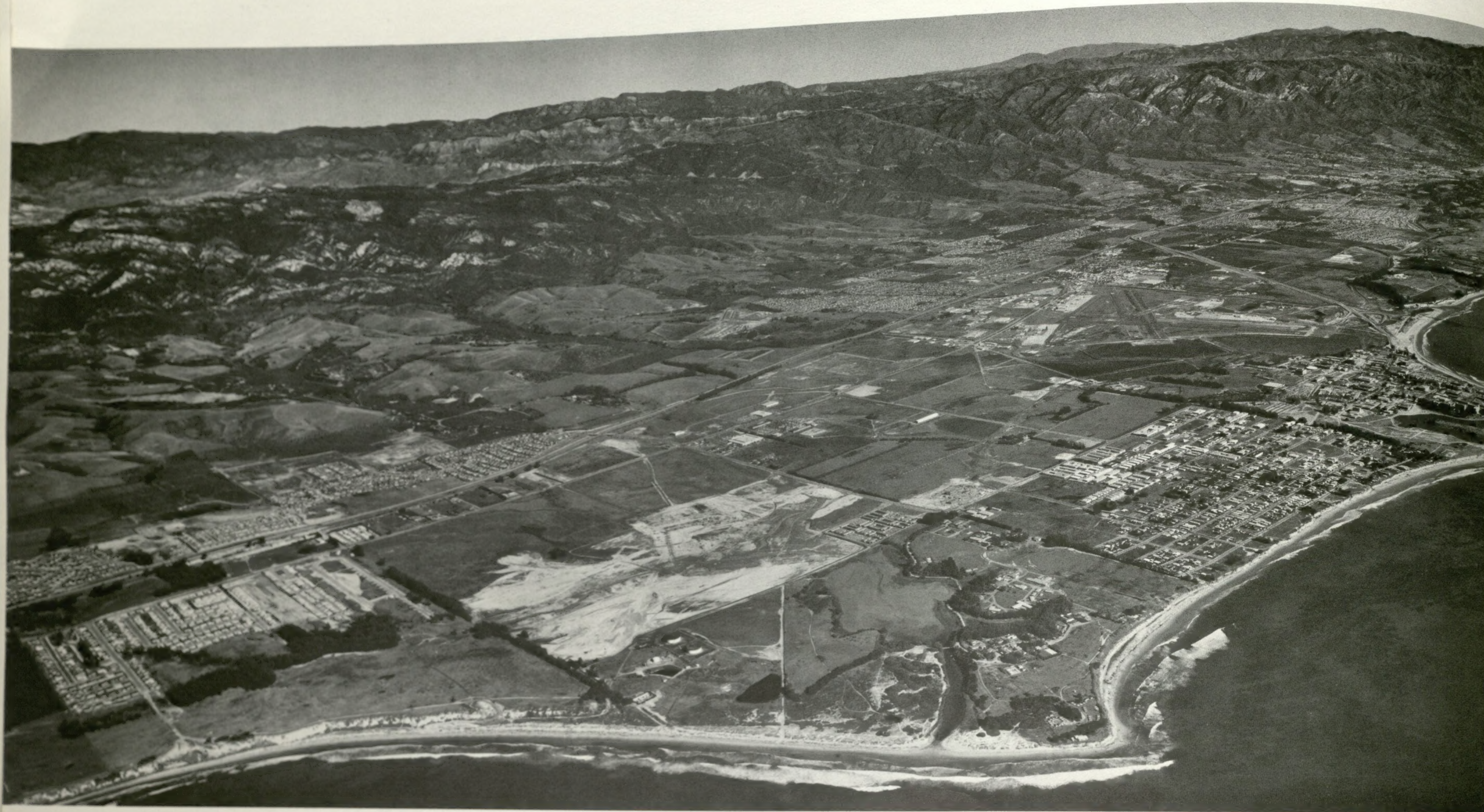

The Goleta Watershed

Photo by Mark Hurd Aerial Surveys

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ACKNOWLEDGEMENTS

The project which is the subject of this report was authorized by the State Soil Conservation Commission, State of California, under the terms of an enabling act, AB 1144, and amendatory acts thereto. The work subsequently undertaken was financed with matching funds supplied by the Santa Barbara County Flood Control and Water Conservation District and the State Soil Conservation Commission, State of California, through the Santa Barbara Soil Conservation District.

The work was done under the direction of a coordinating committee made up of representatives of various county, state and federal agencies. The members of the committee were Cornelius G. Ullman of the Division of Soil Conservation, State of California; Donald M. Hansen of the Soil Conservation Service, U.S. Department of Agriculture; Warren Barnes of the Forest Service, U.S. Department of Agriculture; George E. Goodall of the Agricultural Extension Service, Santa Barbara County; James M. Stubchaer, Flood Control Engineer, Santa Barbara County Flood Control and Water Conservation District; and P.S. Clarke of the Santa Barbara Soil Conservation District.

Mr. Stubchaer and his staff were responsible for most of the field and office work performed during the four year period covered by the project. Mr. Stubchaer also prepared the section of the report dealing with flood control and the hydrology of the watershed. Mr. Hansen undertook the classification of the soils in the coastal plain and he, with Mr. Goodall, prepared the text on valley soils. Mr. Barnes contributed information on mountain soils and forest service lands. Mr. Goodall also prepared the sections of the report dealing with climate and land use. The history of the region was contributed by Mr. Clarke. Mr. March Phillips of the Flood Control District compiled the text, figures and plates and prepared them for printing.

Special mention is due J.W. Richards and R.M. Coudray for their text on surface geology and E.A. Elevatorski for his section dealing with ground-water geology. Clifford Pauley and William Eaton of the County Planning Department staff assisted in supplying land use, economic, and population data.

Particular acknowledgement is due Mr. Ullman for the invaluable guidance and many helpful suggestions which he provided in organizing the project program and in furthering the work to its conclusion. Acknowledgement is also made for the assistance of Arthur Case, former Flood Control Engineer of Santa Barbara County, the firm of North American Weather Consultants, the United States Weather Bureau and various ranchers and residents within the watershed area.

The authors are also grateful to Father Maynard Geiger, O.F.M., of Mission Santa Barbara for his help in providing references, including some from the Mission archives, that were of special historical interest.

ABSTRACT AND SUMMARY

This report presents the results of a comprehensive survey of the Goleta watershed. A brief history of the area is given with special reference to the droughts, floods and land erosions that have occurred since the early part of the nineteenth century. The report also presents respective chapters dealing with the physiography and climate, geology, ground water resources and soils of the region. In addition, a chapter is devoted to a discussion of the economic development and population growth of the area. Particular attention is given in another chapter to the hydrology of the watershed. This section of the report discusses the rainfall pattern of the area; it discusses the capacity of the region for absorbing this rainfall based upon a knowledge of the existent vegetative covers and soil types; it estimates the capacities of the various stream beds from determinations of their cross-sections and gradients; and it estimates the peak runoffs from the various sub-watersheds as well as the entire watershed. Thus, the report shows the serious flood and erosion potentials of the region and presents data and conclusions which should be useful in planning future management of the Goleta watershed.

Photo 1. Flooding at Santa Barbara Airport, January 24, 1967.

INTRODUCTION

A. PURPOSE AND SCOPE

The concept of comprehensive soil and water conservation planning has been given many interpretations in its applications to soil conservation district work. As applied here, it is considered as an inventory and study of the basic physical land and water resources of the area and the adaptable conservation treatments and applications suitable for agricultural, urban, industrial, recreational and other related needs.

Caution is advised in utilizing the material contained in this report for specific detailed conclusions and appraisals. For example, site conditions relative to geology, soils, and engineering cannot be considered as sufficient to pinpoint detail adequate for specific site recommendations. On the other hand, enough information is available in the text for generalized recommendations. Specific details must be investigated further to develop finalized recommendations and plans.

The outline in Appendix 1 details the elements considered as a state prerequisite for reports of this nature for receiving grant funds.

B. AUTHORITY AND FUNDS

The Goleta Watershed Comprehensive Soil and Water Conservation Planning Project was a joint responsibility of the Santa Barbara Soil Conservation and the Santa Barbara County Flood Control and Water Conservation District with initiatory funds made available under the California State Soil Conservation Commission's grant-in-aid program.

Program authority for the project by the Soil Conservation District is set forth in Division 9 of the California Public Resources Code (Appendix 8 of this report) and as implemented through a Joint Exercise of Powers Agreement provided in Title 1, Division 7, Chapter 5 of the California State Government Code (Appendix 9 of this report).

The following schedule lists the State Soil Conservation Commission Grants to the Santa Barbara Soil Conservation District and coordinated "matching funds" provided under the Joint Exercise of Powers Agreement by the Santa Barbara County Flood Control and Water Conservation District:

Work Plan	Date	State Grant	Flood Control District Matching Funds	Total Amount
I	1/29/62	$2500.	$2500.	$5000.
II	1/29/63	2500.	2500.	5000.
III	10/1/63	2500.	2500.	5000.
IV	9/22/64	2500.	2500.	5000.
TOTALS		$10000.	$10000.	$20000.

C. PROCEDURES

Initiation of the Project involved a series of tactical steps similar to those set up for "Pilot Projects" under the State Soil Conservation Commission's study program of Comprehensive Planning. Details are given in the "Outline of Suggested Project Developments, Procedures, Operations and Reports" and the "Procedural Plan" included as appended materials (Appendix 2).

Project leadership was from the beginning vested in a small Coordinating Committee with P.S. Clarke, Director of the Santa Barbara Soil Conservation District, as Chairman and representatives of the major participating agencies as regular members including: Santa Barbara County Flood Control and Water Conservation District; Division of Soil Conservation of California Department of Conservation; Soil Conservation Service of U.S. Department of Agriculture; Forest Service of U.S. Department of Agriculture and Agricultural Extension Service of University of California.

The concept of a coordinating committee approach in developing procedures and operations, although lacking the discipline of strict administrative direction, provided a consolidated basis of agency cooperation and contributions that would have been otherwise impossible. Considered from the standpoint of overhead and costs alone, the total economy of operations of this type of approach versus a specially employed technical force with necessary administrative and supervisorial overhead would have possibly trebled funding needs without effectively raising the level of project development.

Although the overall guidance of the procedures was generally followed in carrying out project operations special emphasis was placed on basic engineering surveys and related information needed to develop the hydrology of the major stream channels and drainways of the watersheds and subwatershed areas. Moreover, certain localized problems, particularly the orographic influence of the Santa Ynez Mountains of the Coast Range, required special emphasis in developing basic data for hydrologic and related resource information. Three important official activities were concerned and bear recognition.

1. Establishing precipitation stations to determine the special pattern and intensity of rainfall.
2. Securing runoff and stream discharge information from major and minor drainage areas.
3. Determining the capacities of major channels and discharge outlets for flood flows.

CHAPTER I

DESCRIPTION OF THE AREA

A. LOCATION AND GENERAL FEATURES

The Goleta Watershed occupies an area of about 30,000 acres between the Pacific Ocean and the crest of the Santa Ynez mountains that extend westward for approximately 8 miles from generally the westerly limits of the city of Santa Barbara to the vicinity of Ellwood some 10 miles to the northwest. The Santa Ynez mountains slope steeply from altitudes of 2300 to 3700 feet to terraces all of which, except the lowest, lie well back from the coast and are separated from it by alluvial plains. These plains slope gradually to sea level, or to the edge of the lowest terrace about 50 feet above sea level, and are 2 to 3 miles wide. The town of Goleta is situated approximately in the center of the coastal strip, and the Santa Barbara campus of the University of California lies on the coast about 2 miles southwest of the town. The plain around Goleta was formerly utilized to a great extent for agriculture, but much of this area within the last ten years has been taken over by residential, commercial and industrial developments.

Some 16,500 acres of the uplands, and mountainous areas are contained within the Los Padres National Forest. About 50 percent of this land is privately owned with the remainder under the federal jurisdiction of the U.S. Forest Service. Heavy mixed chaparral occupies the upper slopes with riparian growth in the canyon bottoms. Much of the cover burned by the 1955 Refugio Fire has been restored. The lower slopes and valley lands are in citrus orchards, avocado groves, cropland and improved pasture with important urban, industrial and recreational developments proceeding in this locality in response to the regional economy of the Santa Barbara area. The present road system tends to run north and south with no ties across the canyon bottoms except via U.S. 101 Highway or Hollister Avenue. The San Marcos Pass Highway crosses the northeast corner of the watershed. The West Camino Cielo Road and Forest Service fuelbreak runs across the top of the Goleta Basin Watershed, and the Edison Company road provides some access to the interior of the watershed.

B. PHYSIOGRAPHY

The Goleta Watershed is composed of a broad, flat alluvial plain bordered on the south by the coastline and on the north by foothills and terraces, above which the Santa Ynez mountains rise rapidly. Ten major creeks drain the Goleta Watershed into a slough lying south of the town of Goleta, from which drainage is carried to the ocean. These creeks, from west to east, are Glen Annie, Carneros, San Pedro, Las Vegas, San Jose, Maria Ygnacia, San Antonio, Hospital, Atascadero, and Cieneguitas. They all become intermittent upon entering the alluvial plain and, with the exception of Las Vegas, Hospital, Atascadero and Cieneguitas, all extend to the crest of the Santa Ynez mountains, occupying steep deeply-incised canyons from the foothills northward.

The Goleta alluvial plain covers an area approximately eight miles long and up to three miles in width. It slopes gently from all directions into the Goleta Slough, which is now largely fille

E R R A T A

Page, Col., Para., Line				Correction or should read
1	3	2	1	"... of the uplands and ..."
1	3	4	3	"... is now largely <u>filled</u> ..."
2	3	2		values indicated are from different period of record than values in TABLE 1
3				Table 1 revised as follows:

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.
Pinecrest	.94	.99	.97	2.52	6.93	4.52	4.67	1.13	.88	.14	.03	.02
S.B.T.V.Peak	.09	.38	1.61	2.61	3.14	2.91	2.30	1.55	.24	.03	.06	.01

4	1	2	13	"...the existent <u>vegetation</u>..."
5	1	3	5	"... distributed and <u>because</u> the ..."
5	2	1	6	"... for rainfall <u>and</u> the..."
13				Figure 2 & 3; Cumulative Departure Curve indicates the amount of rainfall above or below the long term average in Goleta Valley.
15	1	3	3	"...a degree <u>of</u> erosion,..."
25	1	5	3	"... about five <u>eighths</u> was ..."
30				Table 11 to read:

<u>TABLE 11</u>

	Pinecrest	San Marcos Summit-Tenney	Santa Barbara Botanic Gardens	Santa Barbara T.V. Peak
Years of Record	18			27.82
Unadjusted Mean	26.79			28.94
Adjusted Long Term Mean	23.81	27.58	21.35	

Page, Col., Para., Line				Correction or should read
32	1	1	6	"...Hydraulic <u>Engineering</u> in..."
32	1	2	4	"... receiving <u>more</u> than ..."
33	Table 12			Santa Barbara 1/<u>26</u>/14 San Marcos Pass omit asterisk after "2.15" "1/14" should be "1/<u>26</u>/14"
35	1	1	-	Paragraph should follow last paragraph on page 32
38	3	3	5	"... Watershed map, <u>Plate IX</u>..."
44	2	6	10	"...costs of <u>right</u>-of-ways."
46	3	1	7	"Surface <u>run</u>-off is increased..."
Plates III through XII				Revise watershed boundary as shown below.

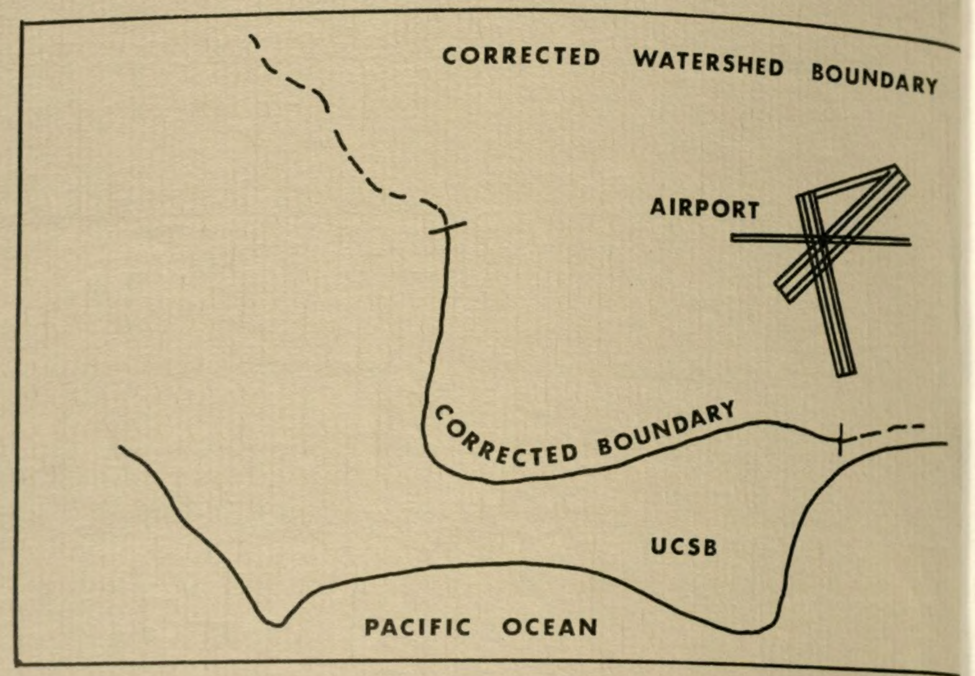


Photo 2. Aerial view of Goleta Valley. Entire watershed drains into the ocean through the Goleta Slough and its outlet in the foreground.

by the normal accretion of sediment and debris from the mountain slopes. The alluvium ranges in thickness from several hundred feet in the central part of the basin to a few feet along the foothills, where it is irregular with long fingers extending up the canyon bottoms.

The coastline of the area is generally a flat terrace ranging from 50 to 150 feet above sea level with a consolidated rock cliff adjacent to the beach except in the vicinity of Mescalitan Island, where the Goleta Slough drains through to the ocean. This terrace generally slopes northward and drains into the slough via the creeks leading to it. The other terraces along the edge of the alluvial plain range in elevation to more than 300 feet above sea level and are generally broad north-south trending ridges which abutt the foothills. The foothills are composed of consolidated rocks and rise rapidly into the extremely steep ridges and canyons of the Santa Ynez Mountains, which have crests 2300 to 3700 feet in elevation.

C. CLIMATE

1. GENERAL WEATHER INFORMATION

The Goleta Valley has a mild subtropical, Mediterranean-like climate. The area adjacent to the coast line is markedly influenced by the Pacific Ocean which gives rise to a "Maritime" zone characterized by a summer fog belt with moderate shoreward winds. A few hundred yards inland a "Coastal" zone type begins which embraces the land to the crest of the Santa Ynez mountains.

The "Coastal" climate zone comprises three identifiable subzones. First is the Goleta "Valley Floor", which is subject to moderate prevailing west winds and winter frosts. Second and lying above the Valley floor is a "Foothill" subzone running to about the 1500 foot elevation. It is the warmest area of the "Coastal" zone with warm summers and little frost hazard. Occasionally hot, dry down-canyon winds are experienced, particularly in spring and **fall**. Generally however, mi
breezes from the west prevail. The third subzone
tain" area, above the 1500 foot elevation. It inc
slopes of the Santa Ynez Mountains. Temperatures
by the elevation. During the winter, occasional s
experienced, which remains on the ground for very
The average snowfall at T.V. Peak (4000 feet) is 2
1.9 inches occurring in January.

Seasonal Conditions: Rainfall occurs princip
winter months of November through March. Total se
vary with elevation and terrain, but in general in
the coast to the mountains. The airport area at G
average of approximately 17 inches: Santa Barbara
17.63 inches: the Pine Crest Station at 1000 feet
averages 26.79 inches and T.V. Peak at 4000 feet e
just over 29 inches.

Variation from season to season is considerable. Santa Barbara's totals vary from 3.00 inches in 1947 to 41.48 inches in 1941. Table No. 1 shows the average monthly and seasonal precipitation for 30 years of record. Table No. 2 gives an analysis of the probability of receiving more than the indicated annual seasonal precipitation. Tables 3 and 4 give details of temperature and evaporation.

Temperatures are mildest and coolest in the "Maritime" zone at the Goleta airport where the annual mean is 58.4°F, the mean maximum is 69.3°, absolute maximum is 99°, mean minimum is 47.9°, and absolute minimum is 26°.

The Santa Barbara City records show an annual mean of 60.3°, mean maximum 72°, absolute maximum 108°, mean minimum of 48.5°, and absolute minimum of 20°. This would be typical of the "Coastal Valley Floor" subzone.

The Pine Crest station at 1000 feet elevation has an annual mean of 61.4° and lies in the "Coastal, Foothill" climatic zone.

Special Information: Santa Barbara's growing season averages 342 days with January 23rd being the last date on which there is a 50% chance of frost.

A seasonal heating degree day is counted for each degree the daily mean temperature falls below 65°. The sum of seasonal heating degree days for Santa Barbara is 2086.

Potential evapotranspiration averages 30.3 inches for the season in Santa Barbara. Annual evaporation averages 69.04 inches at Rancho del Ciervo in the foothills of the Goleta Valley.

Wind measurements made at the Santa Barbara Airport show the prevailing winds are from the southwest. Thirty seven percent of the time it is calm, 60% of the time the wind velocity is between 4 and 15 miles per hour, and 3% of the time between 16 and 31 mph. The strongest winds are from the west.

Light to moderate fog conditions occur at the airport 4.1% of the time, with dense fog 0.2%, and rainy conditions 6.4% of the time.

Unique Fire Weather: The proximity of the ocean makes the fire weather within the upper watershed portion of this area unusual. The point of interaction between ocean and land air is one of unpredictable, violently turbulent wind making for extremely dangerous burning conditions. This point of interaction may lie anywhere on the mountain slopes and varies with the time of day. The period from sundown to midnight is usually one of spectacular burning conditions. With prevailing northerly winds moving downhill, fire spread is most rapid and a pronounced eddy is present which may be felt anywhere on the slope. Under these conditions, control of a mountain fire seems impossible with the present type of control and suppression equipment until the condition ameliorates. It is for this reason that wild uncontrolled large mountain fires, though infrequent, occur as they do. This threat, therefore, is continuously present and is a primary problem on the upper watershed slopes.

TABLE 1

AVERAGE MONTHLY AND SEASONAL PRECIPITATION IN INCHES

	Station	Elev.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Season	Number Yrs.of Record	Period of Record Water Yr.
1.	Dos Pueblos Canyon*	160	.18	.49	2.53	3.70	4.90	4.34	2.95	2.69	.41	.09	.07	.04	22.39	18	1947-48 to 1964-65
2.	Goleta Lemon Co.*	20	.10	.47	1.57	3.10	3.53	3.83	2.95	1.60	.24	.05	.03	.01	17.48	29	1936-37 to 1964-65
3.	San Marcos Trout Club*	1200	.16	.64	2.90	3.92	4.80	5.04	3.09	3.18	.69	.15	T	.07	24.64	20	1945-46 to 1964-65
4.	San Marcos Summit*	2300	.47	1.04	2.04	4.31	6.31	6.07	4.91	2.16	.79	.19	.02	.03	28.34	59	1889-99 to 1914-15 1922-23 to 1963-64
5.	Pine Crest*	1000	.87	.91	.90	2.38	6.40	4.17	4.31	1.04	.82	.13	.03	.02	21.98	18	1897-98 to 1914-15
6.	Santa Barbara	100	.21	.57	2.11	2.76	3.31	3.94	2.72	1.61	.31	.15	.02	.03	17.74	98	1867-68 to 1964-65
7.	S. B. Botanic Gardens*	750	.13	.48	2.74	3.40	4.00	4.16	3.26	2.41	.58	.13	.03	.02	21.34	21	1945-46 to 1964-65
8.	Santa Barbara TV Peak*	4330	.38	.90	3.50	4.00	5.54	8.20	3.17	3.95	.83	.18	T	.01	30.66	9	1956-57 to 1964-65
9.	Santa Barbara Airport*	14	.10	.40	1.71	2.76	3.33	3.08	2.44	1.64	.25	.03	.06	.01	15.81	24	1941-42 to 1964-65

TABLE 2

SEASONAL PRECIPITATION PROBABILITY

PERCENTAGE PROBABILITY OF RECEIVING MORE THAN INDICATED SEASONAL RAINFALL — INCHES

	Station	95	90	75	67	50**	33	25	10	5
1.	Dos Pueblos Canyon*	9.3	11.5	15.8	17.5	21.3	25.8	28.6	36.8	43.0
2.	Goleta Lemon Co.*	6.4	8.3	11.7	13.3	16.5	20.3	22.7	29.5	34.3
3.	San Marcos Trout Club*	10.5	12.9	17.2	19.2	23.2	28.0	30.8	39.5	45.7
4.	San Marcos Summit*	9.3	12.2	17.6	19.9	25.4	31.2	34.9	45.6	53.6
5.	Pine Crest*	9.2	11.3	15.2	17.0	20.7	24.8	27.2	34.9	40.2
6.	Santa Barbara	6.9	8.9	12.0	13.2	16.4	19.7	22.0	28.3	32.7
7.	S. B. Botanic Gardens*	8.2	10.8	14.7	16.3	20.3	24.4	27.1	35.0	40.8
8.	Santa Barbara TV Peak*	11.5	15.1	20.2	22.8	28.0	34.8	37.2	48.0	55.8

*Short record adjusted to long-term values by Santa Barbara Gage (98 yrs. 1867-68 to 1964-65).

**Probability of the Average Event is 43%

Table 3

TEMPERATURE MEANS AND EXTREMES

degrees Fahrenheit

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Pine Crest Mean Temp.*	55.2	56.0	55.8	58.1	58.2	63.4	67.6	68.1	68.3	65.5	62.1	58.2	61.4
Santa Barbara													
Highest	84	88	92	96	98	101	108	98	104	103	97	92	108
Mean Max.	64.8	65.7	67.9	69.7	71.8	73.8	77.7	78.1	78.6	75.6	72.8	67.4	72.0
Mean Temp.	52.6	54.0	56.0	58.6	61.1	63.3	67.1	67.4	66.8	63.1	58.5	54.7	60.3
Mean Min.	40.3	42.2	44.1	47.5	50.3	52.8	56.5	56.7	54.9	50.6	44.2	42.0	48.5
Lowest	20	27	30	35	37	42	44	48	38	34	28	25	20
Santa Barbara Airport (Goleta)													
Highest	86	84	87	90	90	90	97	90	97	99	92	87	99
Mean Max.	63.6	63.9	65.8	67.4	69.9	71.5	73.5	74.3	74.6	72.2	70.3	65.1	69.3
Mean Temp.	51.0	52.9	54.7	57.6	60.0	61.9	64.6	64.8	64.5	61.2	56.9	53.1	58.4
Mean Min.	38.6	41.8	43.7	47.8	50.0	52.4	55.7	55.3	54.4	50.1	43.7	41.5	47.9
Lowest	26	31	33	33	39	41	45	43	42	37	31	28	26

*Average of 7 AM, noon, and 6 PM readings

Table 4

AVERAGE MONTHLY AND ANNUAL EVAPORATION

in inches

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Carpinteria (Reservoir)	3.91	3.47	4.74	5.25	6.23	6.03	6.94	6.23	5.40	4.71	4.11	3.66	60.68
Goleta (Rancho del Ciervo)	4.06	3.70	5.43	5.58	6.91	7.47	8.06	7.25	6.60	5.67	4.50	3.81	69.04

The consequences of heavy rainstorms in the Goleta region have been so significant, however, that they warrant consideration in some detail. Since the tremendous rains of 1861-62, the only rains that appeared to merit unusual comment during the remainder of the nineteenth century were those of 1883-84 in which a rainfall of 34.5 inches was recorded. Unfortunately, no details of the storms of that particular time have been located and it remains for the records of the rains in the 1909-14 period to provide us with detailed accounts of what the consequences of unusually heavy rains can be.

In January, 1909, after a seasonal total of only 5.2 inches to the end of 1908, 12.6 inches more fell by January 26, most of it in the final five days. Until the final day, no serious damage in the Goleta area had been noted, although lower Santa Barbara was flooded and train service had been interrupted. After an additional 2.4 inches, however, Hollister Avenue was washed out, San Jose and Maria Ignacia creeks overflowed and there was heavy damage to roads, bridges and barns.

The heavy rains of March, 1912, totalled 8.5 inches and fell over a period of seven days. Although 2.8 inches was recorded in the last 24 hours, the resultant damage was minor compared with that from the January 1909 storm, probably because the antecedent precipitation was more distributed and becasue the soil was relatively dry before the storm arrived due to a seasonal total of only 3.2 inches to March 1.

The torrential rains of January 1914, in particular those in the two-week period beginning January 15, were the most destructive in recent times. A log of this flood period is given in Appendix 4. It is apparent that the sixteen inches of rainfall, climaxed by over four inches in two hours on the final day, caused enormous damage in both urban and rural areas.

Unusually heavy rains were also experienced in January, 1916, March, 1938, January, 1943, January, 1952, February, 1962, November, 1965, and January, 1967. A relatively light rain on the watershed burned by the Coyote Fire caused flash floods in November, 1964. The 1916 flood, although severe, did not cause the heavy damage in Santa Barbara, Ventura and San Luis Obispo counties that was noted elsewhere in the state, particularly in the San Diego area. The 1938, 1943, 1952, 1962, 1964, 1965 and 1967 floods, however, resulted in creek overflows, flooded streets, flooded homes, evacuation of homes, interruption of railroad service and extensive field erosion.

From a study of these rains, it appears that when serious damage from flooding, erosion and siltation is experienced, it is the result of heavy and prolonged rain falling upon a relatively saturated area. It may be reasoned, therefore, that flooding is a function of three variables, namely, rainfall intensity, rainfall duration and area absorptiveness, and it should be theoretically possible to predict flood conditions graphically by means of triaxial diagrams utilizing the three above-mentioned variables.

From a practical standpoint, it is deemed advisable to center some discussion upon the factor of area absorptiveness, the degree to which this factor has changed since the Aboriginal Period days, and the effect of such changes upon the development of the Goleta region.

Before the Mission days, the mountain slopes probably did not have much more absorptive capacity for rainfall than at present, since the vegetative cover, as stated earlier, does not appear to have been appreciably different. However, the wealth of vegetation on the Goleta plain, described earlier in this chapter, would have exhibited a much higher absorptive capacity for rainfall that the overall absorptiveness of the watershed undoubtedly was far higher than in any recent times. This infiltration capacity, which may be designated also as a water-intake factor, probably declined to some extent during the grazing era because of the permanent removal of some of the vegetative cover, particularly by sheep.

Further marked declines must have occurred with the extensive loss of vegetation during the 1862-64 drought and to a still greater degree later when much of the soil was plowed and utilized for the growing of grains or row crops. The eventual development of plow pans and the loss of top soil accompanying the periodic erosion of these plowed lands, particularly in the hill areas, would be expected to reduce the intake of the soil still further, and in fact the decline from these causes could become cumulative as the practice was continued. The dismal prospect of continued soil deterioration and soil loss probably was a factor in bringing about the diversion of some of these lands to the growing of tree crops. With the extensive planting of orchards, a welcome improvement in the region's absorptiveness has been, no doubt, realized, in view of the use of cover crops, terraces and non-cultivation with and without supplemental mulches, sods and suitable drainage facilities.

Unfortunately, this improvement can only be temporary, since it inevitably will be overshadowed in time, if not already, by the opposing effects of urban development. Roof tops, paved streets, driveways, sidewalks and patios in the Goleta plain and foothills will unquestionably increase runoff and flood potentials. Such hazards will intensify, of course, as urbanization continues and constitute a clear cut threat not only to life and property but also to the future development of the Goleta area.

The magnitude of the problem and the indicated remedial measures to be considered in the future management of the Goleta Watershed will be brought out in subsequent chapters of this report.

Photo 3. Silt and debris deposits on Hollister Avenue from flood of January 25, 1914.

CHAPTER III

PHYSICAL LAND CONDITIONS

A. GEOLOGY

This section describes the surface geology of the Goleta Basin as it pertains to groundwater occurrence and movement and land use. It is intended as general background information and as a general reference on the Goleta Valley; the reader is cautioned that more detailed geologic and soils information must be obtained if the economic development of any specific site within the Goleta Basin is contemplated.

The geology has been freely adapted from the work of J.E. Upson of the United States Geological Survey (1951). It also draws heavily on the unpublished work done by several engineering geologists on subdivisions and other local projects, the results of which have been filed with the Santa Barbara County Public Works Department. Notable among these geologists and firms are Dr. Donald W. Weaver of the University of California, Dames and Moore, Robert Stone and Associates, Dr. Joseph Riccio and Buena Engineering, Inc.

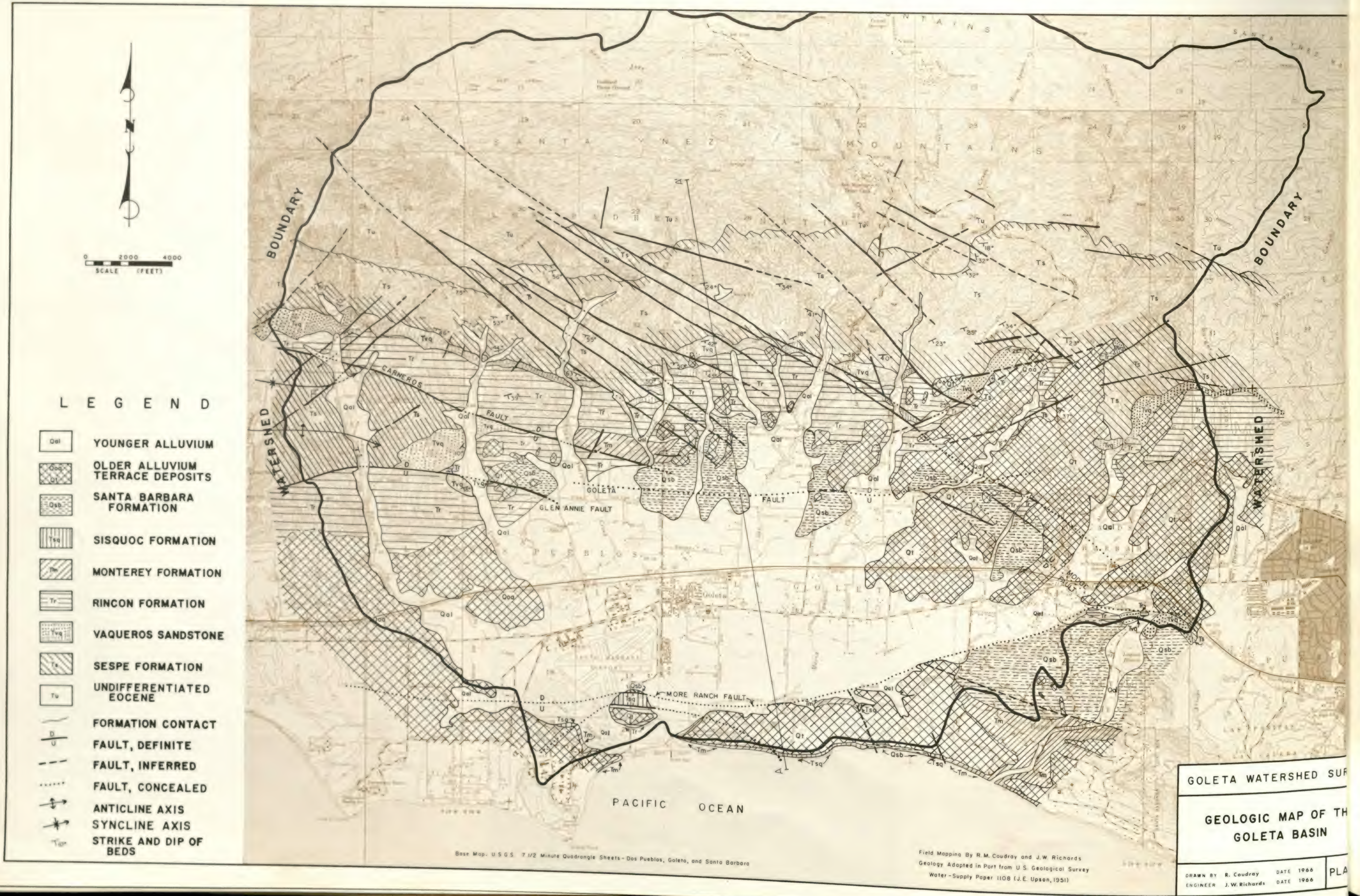
The accompanying map Plate 1 and Figure 1 have been adapted from Upson (1951) where the Quaternary deposits, the Goleta fault, the More Mesa fault and the Modoc fault are concerned. Local areas have been adapted from engineering geological maps. The remaining areas, which cover most of the Goleta Basin were mapped by Ray M. Coudray of the Santa Barbara County Public Works Department between September 1, 1965, and September 1, 1966. The mapping is based on field work done during that period except for the Eocene strata, which were mapped primarily from aerial photos. The field mapping was done on an aerial mosaic, scale 1 inch equals 500 feet, which contains more detail than the small scale map accompanying this report. The field map is available for public inspection at the office of the Santa Barbara County Public Works Department, and interested parties are urged to avail themselves of it.

1. GEOLOGIC HISTORY

A long period of marine and continental deposition from Eocene through Miocene times accounted for over 13,000 feet of sediments which include the Undifferentiated Eocene section and the Sespe, Vaqueros, Rincon and Monterey formations. Contemporaneous subsidence and sedimentation was later followed by upwarping to form the anticlinal arch of the Santa Ynez mountains, and faulting associated with this uplifting is thought to be lost to erosion and time.

As a result of uplifting, the sea retreated and Early Pliocene erosion laid bare rocks as old as Eocene. The re-advancing sea in Late Pliocene time began to deposit silts, muds, and clays in a relatively protected environment. This deposition formed the Sisquoc formation and attained a thickness of over 1,400 feet. Deposition may have lasted into very Early Pleistocene time.

The sediments increased in coarseness, with material being largely composed of debris worn from older Tertiary rocks, and


LEGEND
YOUNGER ALLUVIUM
OLDER ALLUVIUM TERRACE DEPOSITS
SANTA BARBARA FORMATION
SISQUOC FORMATION
MONTEREY FORMATION
RINCON FORMATION
VAQUEROS SANDSTONE
SESPE FORMATION
UNDIFFERENTIATED EOCENE
FORMATION CONTACT
FAULT, DEFINITE
FAULT, INFERRED
FAULT, CONCEALED
ANTICLINE AXIS
SYNCLINE AXIS
STRIKE AND DIP OF BEDS
SCALE (FEET)
0 2000 4000
SANTA YNEZ MOUNTAINS
WATERSHED BOUNDARY
CARNEROS FAULT
GLEN ANNIE FAULT
GOLETA FAULT
MORE RANCH FAULT
PACIFIC OCEAN
Base Map - U.S.G.S. 7 1/2 Minute Quadrangle Sheets - Dos Pueblos, Goleta, and Santa Barbara
Field Mapping By R. M. Coudray and J. W. Richards
Geology Adapted in Part from U.S. Geological Survey
Water-Supply Paper 1108 (J.E. Upson, 1951)
GOLETA WATERSHED SUR
GEOLOGIC MAP OF TH
GOLETA BASIN
DRAWN BY R. Coudray DATE 1966
ENGINEER J. W. Richards DATE 1966
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deposition lasted until middle Pleistocene times. The deposition of these clastics became the Santa Barbara formation. Local basin thicknesses were in excess of 1,000 feet and the anomalous accumulations are thought to have been the result of contemporaneous coastal faulting and irregular basin subsidence.

Coastal uplift, probably in Mid-Pleistocene times, caused an end to marine deposition. Erosion of the uplifted coast and mountains to the North and East yielded coarse clastics to the low-lands of Carpinteria and Summerland; whether these particular continental clastics ever extended as far west as the Goleta Basin is not known.

The inter-glacial period just preceding the Wisconsin stage in the Middle or Late Pleistocene (Bailey, 1943) appears to have accounted for a rise in sea level, and marine terraces were deposited as high as 100 feet above the present levels. Subsequent retreat of the sea and erosion of the highlands resulted in the deposition of Older Alluvium atop the last marine terraces. Channels and deposition were graded to a sea level which was nearly 300 feet lower than the present sea level (Upson, 1951, p. 29); this eustatic lowering appears to be associated with the maximum glaciation of the Wisconsin stage. The main drainages in this area incised into the underlying terraces and breeched the up-thrown block of deformed Monterey shales which forms the South block of the More Ranch fault near Mescalitan Island.

The waning of the last glaciation caused a gradual rise in sea level and deposition to present times has backfilled the channels and flood plains which were graded to a lower sea level with alluvial floodplain and swamp deposits consisting mainly of silts and muds. This process of deposition is continuing at the present time.

2. GEOLOGIC STRUCTURES

The geologic structures of the Goleta Valley and adjacent foothills consist of the southerly-dipping homocline of the Santa Ynez Mountains together with a few minor folds, many large faults and associated minor faults. The few folds appear older than the faults and have little effect upon groundwater aquifers. Subsurface water distribution is chiefly controlled by the larger faults which, in many cases, act as migration barriers.

Two or more possible sets of faults occur in the area and exist in part as strong linear features in the more competent bedrock and are evident on aerial photographs. The oldest and most obscured set strikes to the northeast and the other strikes Eastwest to Northwest. The predominate movement is left-lateral with the north side down; displacements have a greater strike-slip than dip-slip component. Water level studies by Upson (1951, pp. 26, 27) and fault studies by Hill (1932, p. 542) indicate high angle normal and reverse faulting.

The Carneros and Glen Annie faults strike east-west to north-west, both with downthrown blocks to the north, and account for the irregular occurence of Monterey, Rincon, Vaqueros and Sespe formations in the central and westerly portions of the Goleta Valley. Their greatest influence on groundwater occurs where they extend into the underlying Santa Barbara formation aquifer of the Central Goleta Valley.

Differences in water levels led Upson (1951, p. 27) to postulate the existence of the Goleta and Modoc faults. Though no surface trace is present to verify the Goleta fault, water level statistics are strong evidence upon which to infer hydrologic barriers, and thus faults, which strike east-west and north-west.

The More Ranch fault strikes across the southerly portion of the Goleta Valley and upthrown Monterey shales on the South act in part to effectively seal out sea water. Water well logs across this structure show that the Santa Barbara formation is downdropped more than 2,000 feet, and the proximity of wells of differing characteristics across the structure led both Hill and Upson to conclude a very steep fault plane.

The majority of the remaining northwest-striking faults are well defined in the more competent Tertiary outcrops and their greatest influence is from the standpoint of development. Hillside developments should be well aware of the traces of these parallel structures. The orientation of cut faces for both residential pads and roads with respect to the bedding planes and fault structures must be considered. Drag folds adjacent to these structures often produce adverse attitudes which complicate engineering design.

3. STRATIGRAPHY

The rocks and deposits exposed in the Goleta Watershed are Tertiary and Quaternary in age. They are almost entirely sedimentary, and aggregate about 16,000 feet in thickness (Upson, 1951, p. 12).

A continuous east-west band of consolidated rocks of the Tertiary System about 14,500 feet thick is exposed in the Santa Ynez Mountains and is nearly continuous along the foothills. The lower hills and terraces surrounding the alluvial plain display intermittent outcrops of these rocks. Quaternary rocks and deposits totalling nearly 1,500 feet in thickness are exposed mainly on the alluvial plain and the surrounding hills and terraces. The definitions and ages shown in the accompany Table 5 are those determined by R.M. Klienpell and D.W. Weaver (1963) and, in some instances, as summaried by J.E. Upson (1951).

Tertiary Rocks

Tertiary rocks of the undifferentiated Eocene, Sespe, Vaqueros, Rincon, Monterey and Sisquoc formations, described in the following paragraphs, are present in the Goleta Watershed.

Undifferentiated Eocene Strata. The beds mapped as undifferentiated Eocene strata comprise four formations: The Matilija sandstone, the Cozy Dell shale, and the "Coldwater" formation (Upson, 1951, p. 13) of Eocene age, and the Lower Oligocene Gaviota formation (Dibblee, 1950, p. 38). The Matilija sandstone, which occurs only in the upper reaches of San Antonio Creek, is composed of a series of hard buff sandstones separated by thin beds of shale. The Cozy Dell shale, also present only in the upper reaches of San Antonio Creek, is a fairly uniform brown shale which erodes easily and forms topographic lows and saddles. The "Coldwater" formation, which comprises most of the Eocene strata in the Goleta Watershed, is a massive, hard thick-bedded gray and yellow sandstone with interbeds of clay and silt. It forms most of the extremely steep and prominent dip slopes and ridges of the Santa Ynez Mountains and is highly fractured, displaying well-developed joint systems. It correlates with the Sacate formation of the Western Santa Ynez Mountains (Dibblee, 1950, p. 28). These three formations total 7,300 feet in thickness (Upson, 1951, p. 13), and are overlain by the Sespe formation easterly from Carneros Creek. They lie conformably on the Lower Eocene Anita shale in the Western Santa Ynez Mountains. The Gaviota formation is a thick-bedded, massive marine sandstone which forms a narrow but prominent outcrop generally westerly from Carneros Creek. It lies above the "Coldwater" formation and below the Sespe formation.

The Gaviota formation, the Matilija sandstone and the Cozy Dell shale, of limited occurrence, have no major effect on land use. The "Coldwater" formation, of widespread occurrence, normally provides a stable foundation medium but in some areas is subject to landslides, particularly in freshly-graded cuts and fills. The fractures and joints are widespread and, along with shale partings, form pronounced zones of weakness along which sliding is particularly apt to occur if improper cutting and filling are carried on. Septic systems normally perform adequately if located so that the effluent does not enter strata prone to instability. The "Coldwater" formation forms large, often angular, boulders from weathering and as a result of the pronounced jointing. This formation is the source of much of the sediment which has filled the Goleta Slough and of many of the boulders which constitute large-scale debris flows in the creeks during heavy rainfall.

Sespe Formation. The Sespe formation, of Oligocene Age, is a thick series of continental shales, siltstones, sandstones and conglomerates which average about 2,600 feet thick (Upson, 1951, p. 13). The red and green shales alternate with coarse red, greenish and tan sandstones, with the sandstones being coarser and more prominent in the lower part of the formation. A prominent red pebble conglomerate forms the basal unit in the Goleta area. The Sespe formation is exposed in a broad east-west band across the upper foothills and lower Santa Ynez Mountains and in a few scattered localities elsewhere.

The variability of the Sespe formation, both laterally and vertically, makes it impractical to attempt many generalizations concerning its engineering properties. The sandstone beds are usually stable, whereas the more incompetent shales often exhibit surficial creep, shallow landslides and on occasion large deep slides. There apparently is a tendency toward more creep and instability in the western part of the Goleta Basin than in the eastern part, although factual data to support this phenomenon is not available. Septic systems have historically functioned adequately in this formation, with special designs being necessary in some parts of it. Ease of excavation and susceptibility to surface erosion vary with the competency of the particular bed in question.

Vaqueros Formation. The Vaqueros sandstone is a dirty-white to buff, medium to coarse-grained, locally glauconitic massive sandstone with a fossiliferous basal conglomerate in some areas. It is of marine origin and is of Oligocene Age (Kleinpell and Weaver, 1963, p. 118). Its thickness is somewhat variable, averaging about 350 feet (Upson, 1951, p. 14). It forms a prominent brush and oak covered ridge along the lower Santa Ynez mountains and is exposed locally in the lower parts of the Goleta Watershed.

In general, the Vaqueros sandstone is stable and lends it-

TABLE 5

STRATIGRAPHIC UNITS OF THE GOLETA WATERSHED

GEOLOGIC AGE		UNIT & MAP SYMBOL	THICKNESS[1]	GENERAL CHARACTERISTICS	WATER-BEARING CHARACTERISTICS[1]
QUATERNARY	RECENT	Younger Alluvium Qal	0-250'	Unconsolidated loamy clays, silts and gravels. Underlies and forms the alluvial Goleta plain and extends up the main valley stream channels in long fingers. It is usually highly susceptable to surface erosion, and in some parts of the Goleta area it is expansive. Easily excavated.	Yields water moderately, even though saturated to a shallow depth. Often acts as a confining bed.
		— Unconformity —			
	PLEISTOCENE	Older Alluvium Qoa and Terrace Deposits Qt	0-250'	Unconsolidated clay, silt, sand, gravels, pebbles and boulders. Partly marine and partly alluvial in origin. Often caps terraces and foothills. Underlies the Younger Alluvium and has widespread exposures surrounding the central Goleta plain. Rarely expansive, highly susceptable to surface erosion. Easily excavated except for areas of large boulders.	Older alluvium yields some water in the Goleta Basin.
		— Unconformity —			
		Santa Barbara Formation Qsb	1000'	Unconsolidated marine sand, silt and clay. Often a yellowish buff medium to fine-grained quartzose sand with admixed silts and clays. Locally concretionary and fossiliferous. Occurs primarily in the central and southeasterly parts of the Goleta Valley. Rarely expansive, subject to extreme surface erosion, landslide-prone in some areas. Easily excavated.	Sand beds are the main source of well water in the Goleta Basin.
TERTIARY	PLIOCENE	Sisquoc Formation Tsq	1400'	Consolidated marine mudstone and siltstone. Grey to brown, thin-bedded to massive. Locally limy and fossiliferous. Exposed only in the seacliffs and on Mescalitan Island. Susceptable to slumps and landslides along the coastline. Usually over-lain by an expansive thin terrace deposit. Medium to easy excavation.	Not penetrated by water wells; probably low per-meability.
	MIOCENE	Monterey Formation Tm	1000'	Consolidated marine mudstone, siliceous and diatomaceous shales, and local limestone beds. Underlies the Goleta plain with numerous exposures along the seacliff and scattered exposures throughout the Goleta Valley. Forms a black often expansive clay soil which is subject to creep. Subject to slumps and landslides in some areas. Medium excavation.	Yields some water from fractured zones outside Goleta Basin.
		Rincon Formation Tr	1700'	Consolidated marine mudstones and shales with irregular limy, ferric-stained concretions and beds. Fissile, greenish-brown in color. Occurs in a broad band along the lower foothills of the Goleta Valley. Weathers to an extremely expansive and creep-prone greenish-black soil. The entire formation is highly susceptable to slumps and landslides, both shallow and deep, and requires special foundation techniques. Easily excavated.	Not penetrated by water wells; very low permeability.
	— ? — ? — ? —				
	OLIGOCENE	Vaqueros Sandstone Tvq	300'-500'	Resistant, massive marine sandstone, dirty-white to buff, medium to coarse-grained, quartzose, locally fossiliferous and silty. It is in normal and fault contact with the overlying Rincon formation and the underlying Sespe formation and forms a dis-continuous ridge and dip slope across the foothills of the Goleta Valley. It provides a stable foundation medium and is medium to difficult to excavate.	Fresh water obtained at shallow depth in a few wells; not fully explored.
		Sespe Formation Ts	2600'	Consolidated continental mudstones, siltstones and sandstones with a basal unit of pebble conglomerate. The color is variable from green and red clays, silts and sands to tan and buff massive sandstones. It is exposed in a broad band along the foothills and lower Santa Ynez Mountains. Its susceptability to erosion and in-stability is variable, apparently with instability being more pronounced near the westerly edge of the Goleta Basin. Ease of excavation is variable, depending upon the location of massive sandstones.	Not tapped by water wells but has yielded large flows to some oil-prospect wells.
	EOCENE	Undifferentiated Eocene Tu	7300'	Consolidated shales, siltstones, and sandstones of marine origin. It forms the main part of the Santa Ynez Mountains. Susceptability to erosion is variable. Some parts are subject to landslides, particularly in man-made cuts and fills. Ease of excavation is variable, depending upon the location of massive, hard sandstones.	Yields some small artesian flow; not tapped by water wells in Goleta plain.

[1]Upson, J.E., Geology and Ground-water Resources of the South Coast Basins of Santa Barbara County: USGS Water Supply Paper 1108, 1951.

self well to construction except that it sometimes forms slopes too steep to be utilized efficiently and sometimes requires extraordinary excavation techniques. It often weathers into large boulders, some of which constitute boulder flows in the creeks during heavy rainfall.

Rincon Formation. The Rincon formation is a series of uniform, greenish-brown, fissile marine mudstones and shales with irregular, limy ferric-stained concretions and beds. It is of Early Miocene and Early Middle Miocene Age (Klienpell and Weaver, 1963, p. 111), and averages about 1,700 feet in thickness in the Goleta Basin. Outcrops occur in a broad band across the lowermost parts of the foothills and in isolated areas elsewhere. It weathers to a deep greenish-black soil which is characterized by an abundance of yellowish-brown concretions and nodules.

The Rincon formation is extremely susceptible to landslides, creep and other forms of mass movement; it forms low hills which are renowned for instability. The weathered material is highly expansive, with volume changes that range up to 15-20 percent in an unconfined state. Extraordinary engineering and construction procedures are often necessary to rectify instability and provide safe building sites and roads; in some areas development of any type is not feasible. If a stable area is utilized, special foundation design is necessary because of the heaving and shrinking of the expansive materials. Individual septic systems, although used in some areas, are not advisable. Percolation rates are often quite low, requiring large specially designed systems. Also, these systems introduce water into soil and rock formations, thus increasing an already-present tendency towards instability. Excavation is easy to accomplish with ordinary earthmoving equipment but cut slopes and fill areas tend to be unstable if done on any moderately large scale. Any contemplated development in the areas composed of Rincon shale should from the start be carried on with the aid of competent engineering and geological advice.

Monterey Formation. The Monterey formation, of middle and late Miocene Age, is composed predominately of thin-bedded hard siliceous marine shales, some massive mudstone, diatomaceous shale, and local limestone and volcanic beds in the lower part. It averages 1,000 feet in thickness. The beds are locally highly fractured and impregnated with tar, and fumaroles are known to exist in some parts of this formation. In surface exposures the beds are normally white and locally stained with limonite; the fresh unweathered material is usually bluish-gray. The Monterey formation occurs along the sea cliff and in a discontinuous, sporadic belt along the northerly side of the Goleta alluvial plain.

The Monterey formation weathers to a deep, black, heavy soil which tends to creep downhill and may be expansive. The formation is highly fractured and subject to large landslides in some areas. These fractures, coupled with bedding planes, must be considered and planned for in grading operations to avoid block-glide type landslides. Excavation is usually possible with normal earthmoving equipment. Although private septic systems function in parts of this formation, it is advisable to avoid them if possible. Percolation rates are often slow and dry wells are often necessary. The additional groundwater introduced by private systems is undesirable and can be dangerous in areas of questionable stability, such as the sea cliffs.

Sisquoc Formation. The Sisquoc formation, of Pliocene Age is a series of consolidated marine thin bedded to massive, locally limy and fossiliferous, gray to brown mudstones and claystones which average 1,400 feet in thickness. It occurs only along the sea cliffs in the Goleta Basin.

Photo 4. Sloughing of seacliffs accentuates need for adequate building setbacks.

The Sisquoc formation weathers to a black soil that is expansive on occasions. It is locally fractured and subject to landslides along the sea cliffs if improperly worked; some areas require corrective stabilization work before development can proceed. Private septic tank disposal systems perform in the Sisquoc formation but often require special designs; they are not advisable. Excavations proceed easily with normal earth-moving equipment.

Quaternary Rocks

The Pleistocene and Recent deposits are composed of the Santa Barbara formation, several different deposits of alluvium and terrace deposits, both marine and fluvial, and minor amounts of wind-blown material. They total 1,000 to 1,500 feet in thickness and occur throughout the Goleta Basin and the Lower Foothills.

Santa Barbara Formation. The Santa Barbara formation, of Early Pleistocene Age, is composed of about 1,000 feet of unconsolidated sands, silts and clays. It is usually a yellowish-buff medium to fine-grained quartzose sand with admixed silts and clays, and is locally concretionary and fossiliferous. It occurs primarily in the central and southeasterly parts of the Goleta Valley.

The Santa Barbara formation is normally easy to develop with some precautions. It is, in some areas, susceptible to deep-seated landslides and, in those scattered locations, is better avoided. It is highly susceptible to surface erosion in graded areas, and special precautions are necessary to control it. Private septic systems perform adequately, but their relation to steep slopes, graded areas, road cuts and structures must be considered in order to avoid seepage and in order not to increase any inherent instability. Being largely uncemented, the formation is easily excavated, and it makes good fill material. There are, however, occasional thin layers of well-cemented sands which are difficult to excavate and require ripping. If any large-scale development is contemplated, the advice of a soils engineer is advisable.

Terrace Deposits. The terrace deposits, of Late Pleistocene Age, consist of a relatively thin cap of unconsolidated clastics resting unconformably on marine terraces. The thickness is less than 100 feet, and the deposits are comprised of a basal boulder-cobble zone overlain with poorly-sorted detrital pebbles, sands, silts and clays. Upson (1951, p. 24) noted an irregular veneer of eolean or beach sand on the lower-most terraces in the southerly portion of the Goleta Valley.

The terrace material is neither extensive enough nor thick enough to act as a suitable aquifer. Development is easily accomplished except in the lower boulder-cobble zone, where excavating may be difficult. Graded slopes are very susceptible to erosion and precautions must be exercised. Individual septic system performance is satisfactory except for isolated areas, provided the proximity to graded areas, road cuts and steep slopes is considered to avoid effluent seepage and slope instability.

Since these clastics lie unconformably over older formations which may have inherent stability problems, it would be advisable to consult a soils engineer for large-scale developments.

Older Alluvium. The Older Alluvium, of Pleistocene Age, varies in thickness with a maximum of over 200 feet in the Goleta Valley. This material unconformably overlies older consolidated rocks except where terrace deposits were deposited, and immediately underlie the older alluvium. This reddish-brown to tan, unconsolidated detrital material consists of several bodies of admixed boulders, cobbles, pebbles, sands, silts and clays, and forms one of the groundwater aquifers for this area.

Development is easily accomplished except for the large boulder zones which may require blasting. Erosion is of primary concern in any development in this material, and all graded slopes should be protected from surface waters to minimize ravelling. Old unprotected railroad and highway cuts show evidence of high angle slope stability, but are badly eroded from surface runoff.

Septic tank disposal systems perform very erratically in this material. The gross heterogeneity and discontinuous clay layers often act to seal effluent percolation. Impervious layers cause lateral migration and seepages have occurred in cuts downslope. Any development in this material should discourage individual septic tank disposal systems in favor of public sewer service.

Younger Alluvium. The Younger Alluvium, of Recent Age, underlies the Goleta plain and extends as valley fill up the canyon bottoms which drain into the basin. The thickness varies from a feather edge on the north to nearly 225 feet in the southerly portion of the valley. This thickness corresponds to a pre-existing basin which was graded to a sea level nearly 300 feet lower than the present level (Upson, 1951, p. 25). The alluvium consists of mud, silt, sand and discontinuous basal gravels.

The alluvium which has been derived from the Monterey and Rincon formations often exhibits expansive tendencies; therefore, qualified engineers should be consulted prior to designing foundations or grading plans.

Photo 5. *Unconsolidated terrace deposits unconformably overlying Rincon Shale.*

Septic tank disposal systems generally perform adequately and development in the Younger Alluvium should pose little difficulty.

4. GEOLOGY AND LAND DEVELOPMENT

Geologic Problems

In areas such as the Goleta Valley, where the relationship between the rise of mountains and erosion is such that relatively rapid landsliding, large-scale erosion and other forms of mass movement are necessary to restore and maintain equilibrium, and where man's own activities can result in instability through improper grading procedures, rerouting of drainage systems and other changes to the natural setting; man must be increasingly aware of geologic problems and their effects on his works.

Soil Creep, Settlement and Subsidence. The soil mantle on hillsides is subject to slow but continuous downhill movement known as creep, particularly on hillsides composed of clay. Gravity acts continuously and, even if movement is very slow, the result on structures improperly placed and constructed is inevitable failure.

GENERALIZED GEOLOGIC SECTION
ACROSS THE GOLETA VALLEY
SECTION A—A'

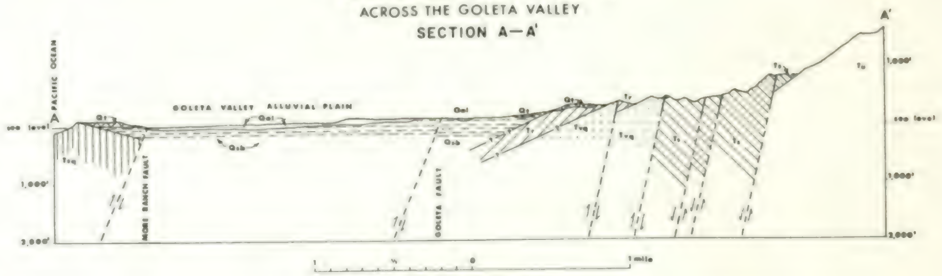


FIGURE I

Photo 6. *Soil creep on a denuded hillslope of Rincon shale.*

Structures or fill placed on canyon-bottom alluvium, uncompacted fill, swamp or slough deposits and other areas which have undergone rapid deposition are usually subject to settlement which often results in destruction of the buildings or other works if proper foundation procedures are not followed. Subsidence of a deep-seated nature has also been noted in various parts of Southern California and must be guarded against.

Expansive Soils. Soils with certain clay minerals change volume with changes in moisture content, resulting in high stresses and possible structural damage. As noted elsewhere, several of the geologic formations of the Goleta Valley are composed of and weather into expansive soils.

Landslides. "Landslide" denotes downward and outward movement of slope-forming materials composed of natural rock, soils, artificial fills or combinations of these materials, but does not include surface creep or subsidence. It may proceed downward by falling, sliding or flowing. Landslides, both ancient and recent, are prevalent in the low hills, foothills and mountains of the Goleta Watershed and constitute the most spectacular geologic hazard; they include the heavy boulder flows which fill creeks during extreme rainfall periods. Not all landslides are of natural origin; man is the instigator of many by undercutting geologic planes of weakness in the rock, by overloading slopes, by introducing moisture with sewage disposal and irrigation, by changing natural drainage systems and by other changes in the natural environment.

Photo 8. Portion of a landslide in marine terrace sand adjacent to high seacliff.

Photo 7. Landslide in the Sespe formation.

Earthquakes. Geologic and earth science cannot as yet predict the exact time, place and extent of earthquakes, which cause destruction by shock waves and disruption along faults. However, the Goleta Watershed is in an active seismic zone and it must be assumed that an earthquake of sufficient magnitude to cause damage will occur during the lifetime of any structure.

Drainage and Rainfall Cycles. Damage due to flooding and erosion rivals or surpasses that caused by other forms of hazard. Many landslides are in fact the result of erosion removing toe support and otherwise weakening or saturating the earth. Most of the earth materials of the Goleta Watershed are subject to erosion in cut and fill slopes and must be protected by adequate planting or other methods. Surface drainage must be properly maintained and disposed of in order to avoid erosion, ground saturation if possible, and flooding.

Improper development and maintenance of private septic systems, water systems, drainage facilities and irrigation systems can have drastic effects in the hillsides since subsurface plays the critical part in landslides through weakening the strength characteristics of the soil and often acting as a lubricant. The effects of increasing quantities of subsurface waters and moisture may be drastic if proper techniques and precautions are ignored.

Site Evaluation and Development. First, of course, in evaluating a site for development is the recognition of any geologic problems which exist. It must be realized that few hilly areas are devoid of geologic problems such as those previously described. Further, many areas with no problems in the natural state are subject to serious restrictions if grading developments are undertaken. Particularly in the latter respect, the safeguards that result from geologic and soils investigations prior to development justify their costs in that they discover and recognize the hazards which may exist or be caused by the development and which will seriously restrict its use and safety once constructed.

Once the problems inherent in a given site are recognized, the planning should proceed with buildings, cuts, septic filter systems, roads and other features placed so that they avoid the problems, fit their natural surroundings and require a minimum amount of grading. In general, massive grading aggravates and even causes geologic problems, and is to be avoided wherever possible. If extensive grading is necessary, it should be planned with the advice of engineers and geologists and be done within the confines of local grading and building codes, which are designed to insure minimum standards of safety.

B. GROUND-WATER RESOURCES

In the Goleta Valley, the ground-water reservoir is replenished by percolation of surface waters in natural channels, by deep penetration of rainfall on generally highly permeable surface alluvium, and by sub-surface inflow. Disposal of ground-water supplies is by pumped wells, by effluent discharge, by consumptive use of phreatophytes, and by subsurface outflow.

Definitions of the terms used in this section are listed below:

Unconfined Ground-Water — This refers to a ground-water reservoir not overlain by impervious strata, and with movement under control of the water table slope. For unconfined ground-water bodies, changes in ground-water storage are indicated by water level changes.

Confined Ground-Water — A body of ground-water overlain by strata, sufficiently impervious to sever a hydraulic connection with overlying water, and moving under pressure caused by the difference in head between the intake and discharge areas.

Drawdown — The difference between the static water level and the water level remaining constant after a period of pumping.

Aquifer — A water bearing strata.

Specific Yield — This refers to the volume of water a saturated sample of a water-bearing material will yield by gravity, divided by the volume of that sample and commonly expressed as a percentage. Ground-water storage capacity is calculated as the product of the specific yield and the volume of the material in the depth intervals considered.

Safe Yield — The maximum rate of net extraction from the ground-water basin which could be maintained throughout a critically deficient water supply period balancing supply with demand.

Overdraft — The net use of ground water that is in excess of the safe yield.

Occurrence of Ground-Water. In the Goleta Valley, ground-water is obtained from wells drilled into unconsolidated deposits, and the Santa Barbara Formation. The areal extent of these water-bearing formations is shown on Plate II.

The water-bearing formations are bordered by consolidated rocks on the north and west margins of the valley and on the south, they are truncated by consolidated rocks which have been uplifted by faults. Consequently, a large portion of unconsolidated deposits are separated from the ocean by consolidated rocks.

Source and Movement of Ground-Water. In 1960, Evenson and Wilson (1962) reported that the Goleta ground-water basin can be subdivided into four sub-basins which are separated by three distinct hydrologic barriers.

[1] *R.E. Evenson and H.D. Wilson, Jr., "Yield of the Carpinteria and Goleta Ground-Water Basins, Santa Barbara County, California, 1941-58, U.S. Geological Survey Open-File Report, 1962."*

The central sub-basin occupies the south-central portion of the valley and is separated from the east sub-basin by a hydrologic barrier that strikes northwest. This barrier is belived to be related to the Modoc Fault system and was identified by the large difference in water levels on opposite sides of the barrier. The northern barrier is the Goleta Fault, and portions of the Carneros and Glen Annie Fault systems.

The central sub-basin is separated from the west sub-basin along a hydrologic barrier that lies between San Pedro and Carneros Creeks. The west barrier results from facies changes and difference in permeability of the unconsolidated sediments.

The consolidated deposits of the central sub-basin contain two aquifers: (1) a shallow water body contained in the upper beds of the younger alluvium, older allumium and terrace deposits, (2) a deep water body in the older alluvium and in the Santa Barbara Formation.

The deep water body, which is the source of most of the water pumped, is partly confined and the approximate area of confinement extends south of Hollister Avenue.

Ground-Water Storage. Ground-Water in storage is estimated from the volume of saturated sediments and the specific yield of these sediments. Once determined, changes in ground-water storage may be calculated by changes in water levels throughout the sub-basins. During the period 1941 through 1964, the ground-water in storage has been estimated to fluctuate from 40,000 to 60,000 acre-feet.

Water-Level Fluctuations. Water levels in the Goleta Valley have fluctuated widely as shown in the hydrograph of two selected wells, Figures 2 and 3.

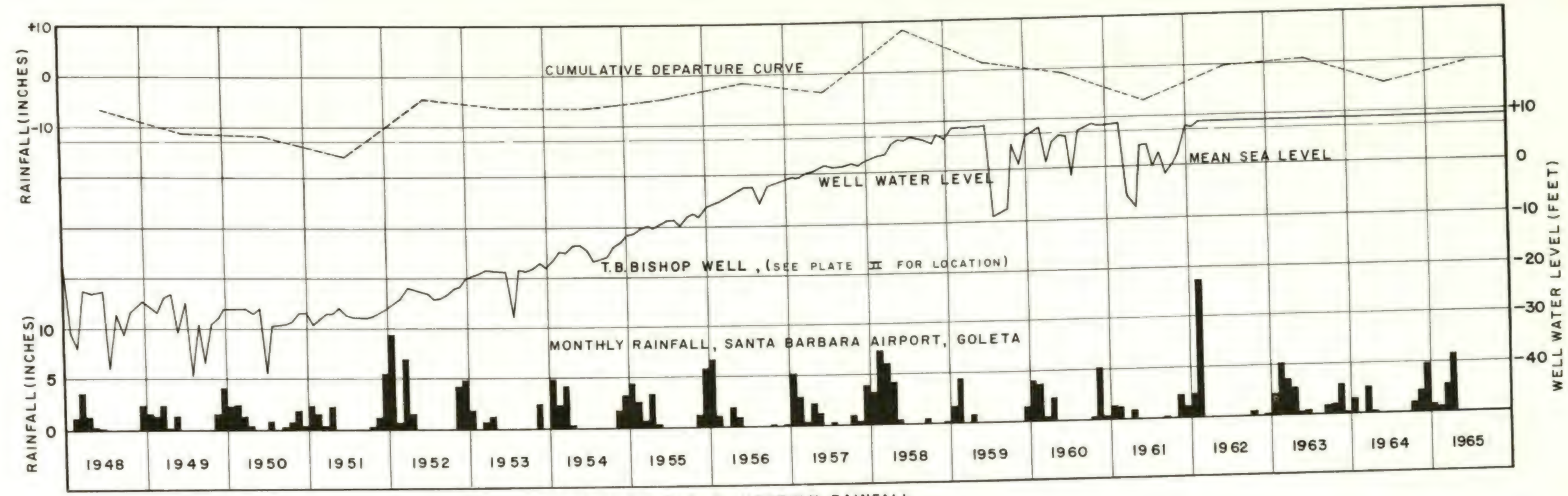
In general, the water levels declined from 1941 to 1956. With the water deliveries from the Cachuma Project, the water levels have risen and in some areas have recovered to the 1941 level. A continuing rise in the water levels may lead to drainage problems for new housing developments and damage to building foundations.

Recharge. Known recharge to the ground-water is primarily from infiltration of precipitation and seepage losses from streams. Average annual recharge from rainfall infiltration and seepage losses have been estimated (Evenson and Wilson, 1962) as 2500 and 1400 acre-feet, respectively. Return irrigation water to the deep water body was considered to be only several hundred acre-feet. No data is available on the subsurface inflow, entering from fractures in consolidated rock areas north of the Goleta Valley, but it is generally considered substantial. Plate II indicates highest areas of recharge.

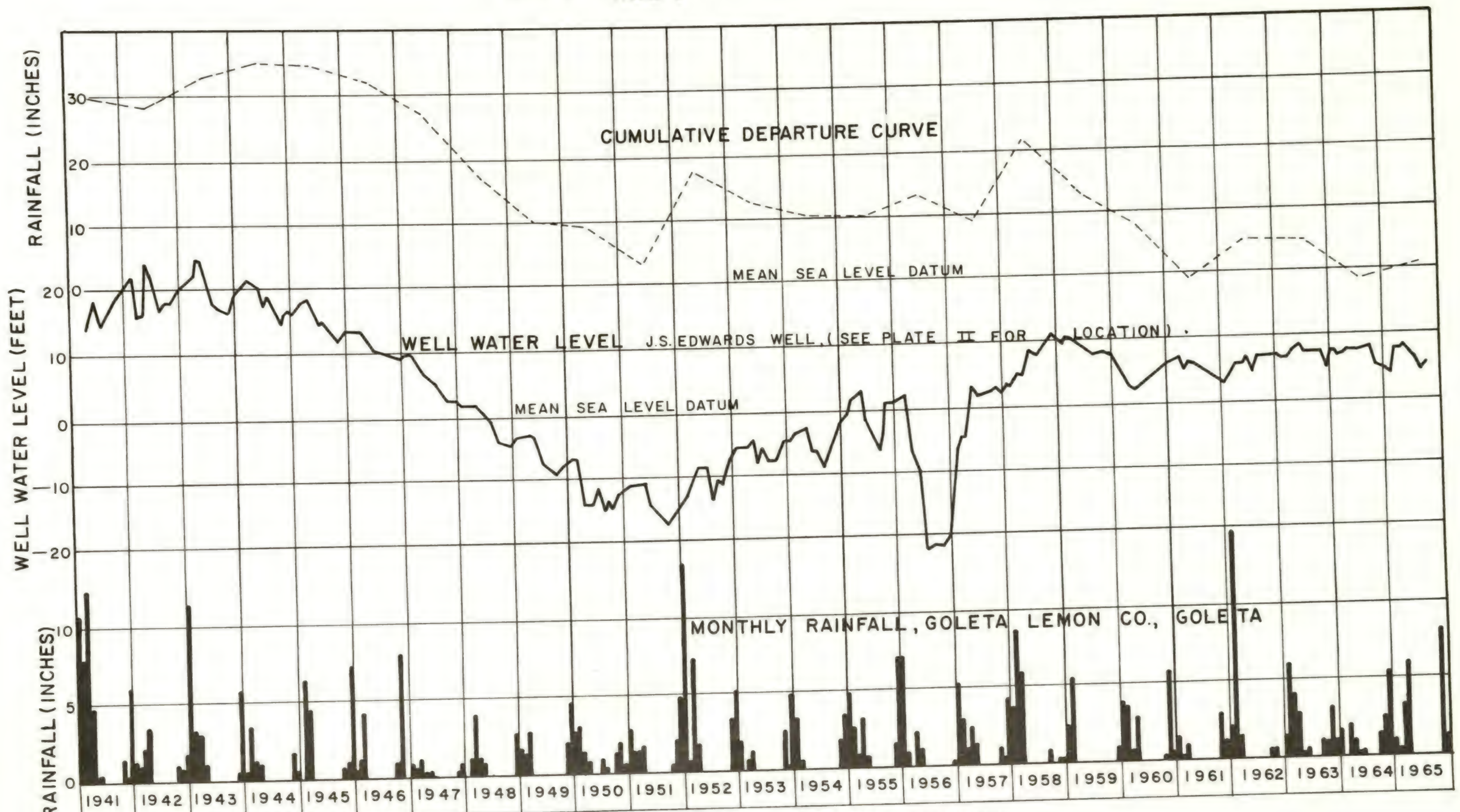
Safe Yield. The safe yield for the Goleta Valley has been estimated at 5800 acre-feet per annum (Evenson and Wilson, 1962). This was adapted from a relationship between average annual net change of ground-water in storage from a period in which climatic conditions approximate the long-term average. For the period 1941-1958, an average annual pumpage of 6600 acre-feet produced a total depletion in ground-water storage of 13,000 acre-feet, or about 800 acre-feet per year. Using this relationship, the indicated long-term annual safe yield is 5800 acre-feet.

Photo 9. Water well under construction near San Jose Creek and Berkeley Drive. Photo by Goleta County Water District.

N
0 2000 4000
SCALE (FEET)
LEGEND
RECENT
QAL
RECENT ALLUVIUM
PLEISTOCENE
QOAL QT
OLDER ALLUVIUM & TERRACE DEPOSITS
QSB
SANTA BARBARA FORMATION
BOUNDARY OF AREA OF CONSOLIDATED ROCKS
FAULT (CONCEALED WHERE DOTTED, INFERRED WHERE DASHED)
SELECTED WELL (WATER LEVEL & YEAR)
NOTE:
ALL WATER LEVELS ARE IN FEET BELOW LAND SURFACE DATUM
WATERSHED
BOUNDARY
SANTA YNEZ MOUNTAINS
LOS PADRES NATIONAL FOREST
GLEN ANNIE FAULT
GOLETA FAULT
MORE RANCH FAULT
38.58 | 1965
43.94 | 1945
49.97 | 1965
42.35 | 1945
113.49 | 1965
88.87 | 1945
48.88 | 1965
35.85 | 1945
41.60 | 1965
71.40 | 1945
FLOWING | 1965
26.12 | 1945
12.05 | 1965
41.51 | 1945
J. S. EDWARDS
BISHOP RANCH
QAL
GOLETA WATERSHED SURVEY
GOLETA VALLEY STUDY
WATER-BEARING FORMATIONS
DRAWN BY A. Meehan DATE 1966
ENGINEER E. Elevatorski DATE 1966
PLATE 3



WELL LEVELS & MONTHLY RAINFALL
FIGURE 2



WELL LEVELS & MONTHLY RAINFALL
FIGURE 3

C. SOILS AND INTERPRETATIONS

1. SOIL SURVEY CLASSIFICATION AND USES

The soil survey in this report and its various soil groupings will serve several purposes. It will help people interested in knowing about the soils and their agricultural capabilities. It will provide needed soil information and interpretations of the behavior of soils for urban dwellers. It also adds to our knowledge of soil science.

Soil survey interpretations provide users of soil maps with predictions about the behavior of each kind of soil under defined situations. Reliable interpretations can result from a synthesis of basic data about the soils themselves, obtained from field and laboratory research, data from field experiments, and the users of soils, especially farmers, ranchers, foresters, and engineers.

To serve the needs of various users, both specific and general interpretations are needed. Each interpretation needs to be designed for its unique purpose with the greatest possible simplicity of expression without loss of any necessary exactness. Then its use should be strictly limited to its purpose. Mistakes result from using interpretive groupings for a purpose for which they were not designed. In groupings for unlike purposes, soils that are placed together for one purpose will fall into separate classes in another.

The description of the individual kind of soil and the data about it are specific. As soon as any two kinds of soil are grouped together, some precision has been lost. But if the purpose is narrowed and clearly defined, considerable simplicity can be had without great loss of specificity.

Broad groupings are necessary for developing and interpreting general maps of counties and states used for program planning. These groupings are best made by combining narrower and simpler ones.

Interpretations of the behavior of the kinds of soil are predictions, and should never be considered recommendations for use. They furnish only part of the facts and estimates needed for making decisions among possible alternatives of management.

Engineers are interested in certain soil properties because the nature of any given soil can be altered by appropriate manipulation. This affects the use of the soil to support various types of structures or as a construction material from which the structure itself is built. The important soil properties which determine its suitability as a building material and those properties which impose limitations or special requirements for its use in construction are strength, permeability, compaction characteristics, shrink-swell behavior, water holding capacity, grain size, plasticity, and soil reaction. Laboratory analyses are often limited or are unavailable for many soils. The soil map, when correlated with available laboratory analysis, can be used in making generalized estimates of the engineering properties of the soil. The engineering interpretations in this report are generalized and are not intended to eliminate the need for on-site sampling and testing of soil materials for design and construction of specific engineering works and uses.

Photo 10. Agricultural development in Glenn Annie Canyon. View shows various stages of developing steep eroded land for lemons and avocados. Note diversion terraces with controlled outlets. Photo by Al Robertson.

2. SOILS OF THE GOLETA WATERSHED

Many different kinds of soil occur in the Goleta Watershed because of the variety of parent materials. In general, the broad differences in parent material are associated with several distinct soil series and types of landscapes. The soils in this area can be grouped by types as follows (a description of the individual soil series is referenced in Appendix 5):

Soils of the Recent Alluvial Fans and Wind-Deposited Materials. This group contains the most productive soils in the area. They occur mostly on nearly level or gently sloping recent alluvial fans or on recent wind-deposited material of the coastal plain. In general, the soils are deep, permeable, and rather easily worked. The group consists of the Agueda, Baywood, Botella, Carpinteria, Elder, Mocho, Sorrento, and Yolo series.

Soils of the Older Alluvial Fans. The soils of this group are not extensive. They occupy positions on older alluvial fans, generally bordering but higher than the recent or young alluvial fans. The subsoils are somewhat compact and not so permeable as those of soils in the recent alluvial fans. The soil series in this group is the Ballard.

Soils of the Basins. This group is made up of poorly drained dark-colored soils in basin positions. Though their area is small, such soils are important in this area because of their limitations. The Alviso and Clear Lake series are in this group.

Soils of the Terraces. The soils of this group cover wide areas. They generally have either compact, slowly permeable subsoils or cemented lenses in the subsoils. They occur on undulating or rolling old terraces of the coastal plain. Some of the most erodible soils of the area are included. Soil series of this group are the Aliso, Milpitas, Montezuma, Tierra, and Watsonville.

Soils of the Uplands. The soils of this group are by far the most common in the area. They cover much of the southern and western slopes of the Santa Ynez mountains. Large parts of these mountains are very steep and very stony; these areas are not separated into soil types, but are classed as rough broken and stony land. The soils of this group belong to the Gaviota, Los Osos, Maymen, Nacimiento, San Andreas, Sespe, and Zaca series.

Miscellaneous Land Types. Areas where little or no true soils exist are classified as miscellaneous land types. These in the Goleta Watershed are as follows: Coastal bench, Dune sand, Excavated land, Kitchen middens, Landslip, Made land, rough broken and stony land, rough gullied land, Terrace breaks, and Tidal marsh.

3. LAND CAPABILITY CLASSIFICATION

The soils mapped in the Goleta Watershed under standards of U.S. Department of Agriculture, Soil Conservation Service procedures vary widely in profile, depth, slope and degree or erosion, presence or absence of salts, wetness, and other factors. A classification device known as the Land Capability Classification System is used so that agricultural and other conservation management requirements may be systematically reported in accordance with soils and land conditions mapped.

Eight classes have been established in the nationwide system of soil classification. These classes are designated by Roman numerals I through VIII. The classification is divided on two major bases: (1) Lands suitable for cultivation (Classes I through IV) and (2) Lands generally not suited for cultivation (Classes V through VIII). Additional limitations are given by subclass and unit definitions. Details and local interpretations are given as follows:

Land Suitable for Cultivation and Other Uses.

CLASS I: Very good cultivable soils, from all points of view. Soils are nearly level, do not erode readily, and are deep and easy to work; hold water well and are fairly well supplied with plant nutrients; suitable for continuous cultivation and require only normal good management practices.

CLASS II: Good cultivable soils that have minor limitations if used for continuous cultivation.

CLASS III: Moderately good cultivable soils that have major limitations if used for continuous cultivation.

CLASS IV: Fairly good soils; suitable for occasional cultivation under careful management but not suitable for continuous production of cultivated crops. In the Goleta Valley soils in this class are used for citrus, avocado, and fruits.

Land Limited in Use—Generally Not Suitable for Cultivation.

CLASS V: (No Class V soils occur in the Goleta watershed.)

CLASS VI: Well suited to grazing or forestry. In the Goleta Valley some soils of Class VI are used for citrus and avocados.

CLASS VII: Fairly well suited to grazing or forestry; soils have major limitations in use.

CLASS VIII: Not suited to cultivation, grazing, or forestry; soils may be used for wildlife, recreation or watershed purposes.

Subclass. The kind of problems or limitations may vary considerably in any one of the capability classes except Class I. For example, one area may be in Class II because of a drainage problem, but another may be in Class II because of slope that brings about an erosion problem. Practices for correcting drainage are distinctly different from those needed to control erosion, so it is helpful to divide a capability class into subclasses according to the kinds of limitations or hazards encountered in use and management. The four subclasses recognized are shown by a lower case letter as follows:

e = erosion, or slope, or both.

w = excessive water in the soils, or flood hazard.

s = unfavorable soils conditions such as shallowness, very coarse or very fine texture, alkalinity or salinity, and the like.

c = adverse climatic conditions. (None recognized in this area.)

Unit. The soils in the class and subclasses are placed in capability units, which are groups of soils that are nearly similar in major crop adaptability, need practically the same kind of management, and have similar productivity levels. The capability unit shows the specific condition or combination of conditions that limit the use of the soil. The kinds of soils within a capability unit may differ slightly in the management practices they need and in the crop yields they produce.

Photo 11. Land capability units in the Goleta Valley. Symbols indicate class, subclass, and unit as explained in the text.

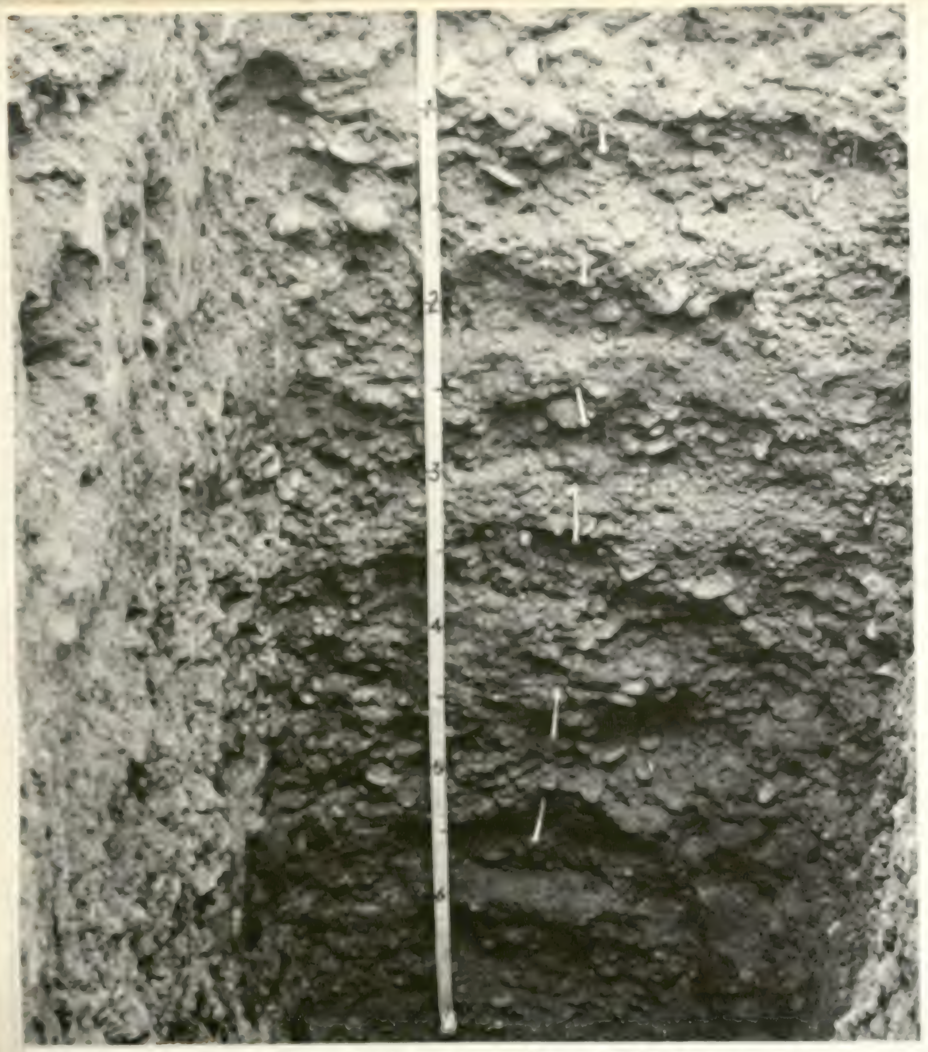


Photo 12. Soil exploration pit in recent alluvial soil, which is deep, well drained, and has no limitations in the profile.

Photo 13. Terrace soil. The clay subsoil (claypan) greatly limits the use of this soil. The erosion hazard is high.

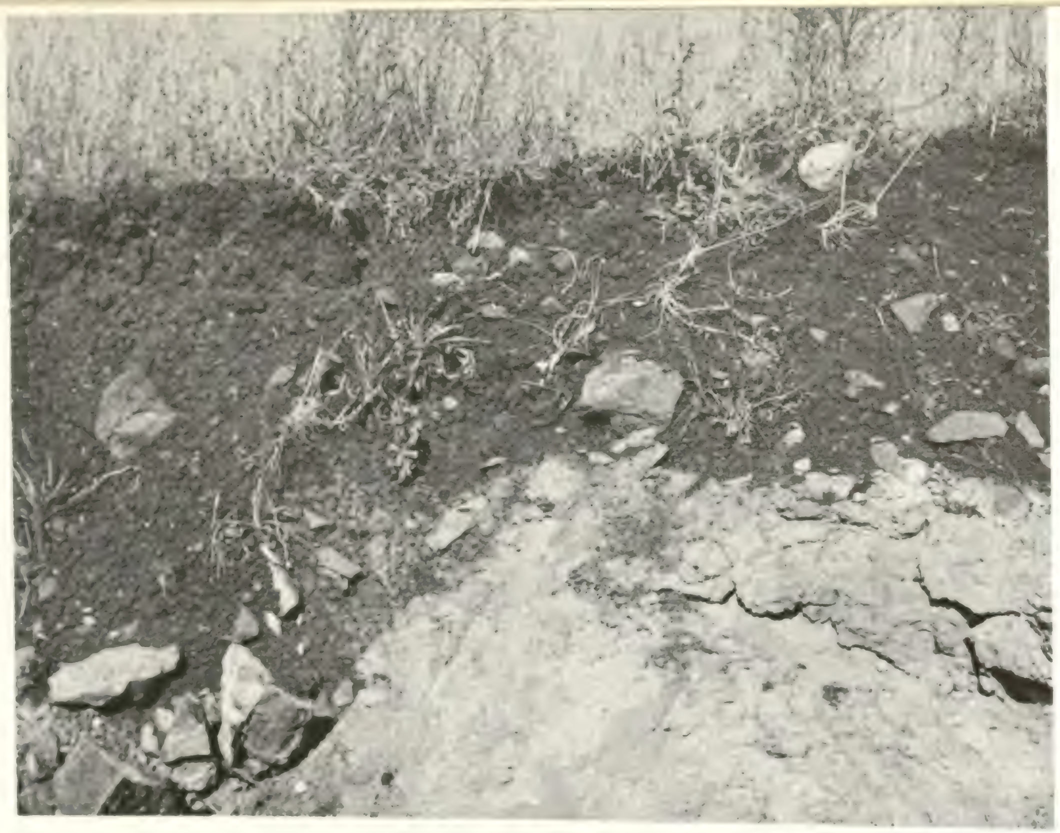


Photo 14. Residual soil. Some of these upland soils are only moderately deep to rock, soft sandstone or shale. These soils present special problems in proper use and management.

Photo 15. Residual soil. Some of these upland soils are only moderately deep to rock, soft sandstone or shale. These soils present special problems in proper use and management.

LAND CAPABILITY UNITS

0 - Coarse underlying material.
1 - Erosion Hazard.
2 - Drainage or overflow.
3 - Slowly permeable subsoils.
4 - Coarse textures.
5 - Fine textures.
6 - Salinity or Alkali.
7 - Stony or rocky.
8 - Cemented layers or bedrock.
9 - Low fertility or toxic elements.

Land capability class, subclass and unit category are characterized by a combination symbol as follows: (Plate III)

VIe3
- Land capability unit category
- Land capability subclass
- Land capability class

The Land Use Capability System of land classifications for agricultural uses provides a highly refined guide for suitable use of land when proper application of economically sound soil and water conservation practices and treatments are applied. It establishes the basis for overall land and water resources conservation on agricultural and watershed wild lands.

4. STORIE INDEX

The Storie Index comparatively evaluates the overall suitability of a soil for agriculture. The four factors considered in arriving at this index are:

A. Profile characteristics.
B. Texture of the surface soil.
C. Slope.
X. Other conditions.

Each factor is evaluated in terms of percentage of ideal, or 100 per cent; the index is then obtained by multiplying together the values of the four factors.

The following explains how each of the four factors is evaluated.

FACTOR A (profile characteristics); expresses relative favorability of the profile to growth of plant roots. The rating depends upon the extent to which root penetration is limited

LEGEND
SCALE (FEET)
0 2000 4000
N
CLASS
A· I & II — NONE TO SLIGHT LIMITATIONS FOR CULTIVATION
B· III & IV — MODERATE TO SEVERE LIMITATIONS FOR CULTIVATION
C· VI & VII — RANGELAND OR ORCHARD WITH SEVERE LIMITATIONS
D· VIII — WATERSHED, WILDLIFE AND RECREATION
"SEE TEXT FOR FULL EXPLANATION"
AVERAGE WATER YEAR ISOHYETS (INCHES)
CREEKS
BOUNDARY
WATERSHED
LAKE
SAN JOSE CREEK
MARIA YGNACIO CREEK
SAN ANTONIO CREEK
CARNEROS CREEK
SAN PEDRO CREEK
LAS VEGAS CREEK
TECOLOTITO CREEK
TECOLOTITO (GLEN ANNIE) CREEK
HOSPITAL CREEK
CIENEGUITAS CREEK
ATASCADERO CREEK
SAN PEDRO CREEK
GOLETA WATERSHED SURVEY
LAND CAPABILITY CLASSIFICATION
DRAWN BY A. Meehan DATE 1966
ENGINEER R. Kovar DATE 1966
PLATE III

N
0 2000 4000
SCALE (FEET)
LEGEND
A---- SLIGHT-NO STONES; OVER 60" TO BEDROCK, GRAVEL MAY BE PRESENT.
B---- MODERATE-PROFILE STONY THROUGHOUT OR BEDROCK WITHIN 30 TO 60 INCHES OF SURFACE
C---- SEVERE-LESS THAN 30 INCHES TO BEDROCK; ROCK OUTCROPS COMMON
AVERAGE WATER YEAR ISOHYETS (INCHES)
CREEKS
WATERSHED BOUNDARY
TECOLOTITO GLEN ANNIE CREEK
CARNEROS CREEK
TECOLOTITO CREEK
SAN PEDRO CREEK
LAS VEGAS CREEK
SAN JOSE CREEK
MARIA YGNACIA
SAN ANTONIO CREEK
HOSPITAL CREEK
CIENEGUITAS CREEK
ATASCADERO CREEK
GOLETA WATERSHED SURVEY
ROCKS AND STONES
DRAWN BY A. Meehan DATE 1966
ENGINEER R. Kover DATE 1966
PLATE IV

FACTOR B (texture of the surface soil); is graded according to the texture of the surface soil, which is important in determining how easily the soil can be worked and how easily crops can be established. The medium textures-fine sandy loam, loam, and silt loam are most favorable.

FACTOR C (slope); particularly important if the land is irrigated. The rating decreases as the slope increases.

FACTOR X (other conditions); is used to evaluate any handicaps to the use of the soil not covered by the other three factors. Salts or alkali, poor drainage, low natural fertility, or unfavorable microrelief are considered in this factor.

The Storie Index is calculated on the basis of soil properties alone. It does not take into account land value, climate, location, markets, or similar factors. The Storie Index rating for the Goleta area is contained in Appendix 6.

5. SOIL FOR NON-AGRICULTURAL USES

Five non-agricultural technical interpretations, all based on degrees of limitations of the soil characteristics are as follows: (1) rock and stones, (2) shrink-swell potential, (3) septic tank filter fields, (4) soil slippage and (5) internal soil drainage. Soil properties and other qualities used in making these interpretations are discussed in this section of the report. The information presented is neither specific nor detailed enough for all planning or engineering needs. It is not meant to be a substitute for on-site investigations or tests of soil samples.

Rock and Stones (Plate IV). Stones in a soil, or bedrock close to the surface, have considerable effect on the excavation of soils for pipelines, roads, channels, or other engineering practices. These also affect the value of a soil for use as topsoil, road fill, reservoir embankments and similar engineering uses. The soils of the Goleta Valley have been classified into three degrees of limitations based on amount of stones present and depth to bedrock. The ratings and the criteria for establishing them are as follows:

Slight - No stones; over 60 inches to bedrock, gravel may be present.

Moderate - Profile stony throughout or bedrock within 30 to 60 inches of surface.

Severe - Less than 30 inches to bedrock; rock outcrops common.

Shrink-Swell Potential (Plate V). The shrink-swell potential is the quality of a soil that determines its volume change with change in moisture content. Damage to building foundations, roads and other engineering structures result from the shrinking, swelling and churning of soils as a result of drying and wetting. This shrink-swell behavior of soils is influenced by the amount of moisture change, the initial moisture content, and amount and kind of clay mineral present in the soil. Three classes of limitations were used to rate the shrink-swell potential of the soils of the Goleta Valley. These limitations were based on the following criteria:

SOIL QUALITY OR PROPERTY	SOIL LIMITATION RATING		
	LOW	MODERATE	HIGH
Soil texture and clay mineral	Sand to silt loam mixed clay minerals or clay loams Kaolinite	Sandy clay loam to clay loam mixed clay minerals	Sandy clay to clay, mixed minerals or montmorillanite
COLE*	Less than 0.01	0.01 to 0.04	Greater than 0.04

*COLE is the coefficient of linear extensibility. It measures the expansion of an undisturbed soil in its natural condition at a moisture content ranging from 1/3 atmosphere to oven dryness. Plate V shows the location of the general ratings defined above.

Septic Tank Filter Fields (Plate VI). The septic tank filter field is a part of the septic tank soil absorption system for sewage disposal. It is the subsurface tile system laid in such a way that effluent from the septic tank is distributed with reasonable uniformity into the natural soil. Criteria and standards used for rating the soils are based on soil properties and qualities. These characteristics are listed as follows:

SOIL QUALITY OR PROPERTY	SOIL LIMITATION RATING		
	CLASS A SLIGHT	CLASS B MODERATE	CLASS C SEVERE
permeability in/hr	Greater than 1.0	1.0 to 0.63	Less than 0.63
Depth to rock (inches)	over 60	30 to 60	Less than 30
Percolation rate (min/in)	Faster than 45	45 to 75	Slower than 75
Water table (ft below surface	Greater than 4	2 to 4	Less than 2
Slope (%)	0 to 9	9 to 16	Greater than 16
Drainage class	Excessively to well	Moderately well to somewhat poorly	Poorly to very poorly

Slippage (Plate VII). Slippage relates to the tendency of of only the soil mantle and fractured material directly below the soil mantle to slide down slope by the forces of gravity. This slippage takes place (1) during or immediately after a heavy or long rain and/or (2) along zones of transition from one material to another.

Soil slippage is an important factor to consider when designing or locating roads, building sites, lined channels and other structural uses of soil.

Soil features affecting slippage are difficult to evaluate. The following are the main considerations: Field observations on past performance of soil slippage are additional criteria. The three degrees of limitation are: low, moderate and high.

SOIL QUALITY OR PROPERTY*	SOIL SLIPPAGE LIMITATION		
	LOW	MODERATE	HIGH
Clay slope %	0 to 15	16 to 30	31+
Clay loam - slope %	0 to 30	31 to 45	46+
Loam, fine sandy loam, sandy loam, loamy sand, sand and claypan soils - slope %	0 to 46+		

*Based on the subsoil texture.

Drainage (Plate VIII). Soil drainage considers the internal drainage and permeability of the soil. High water tables have a tremendous effect on septic tank filter fields, stability of foundations, and types of pipes or conduits which can be used. Soil permeability also affects these same uses of the soil. Because of the relatively impermeable pan or slowly permeable clay textures, runoff is generally quite high. In claypan soils the soil above the pan often becomes saturated rapidly, and forms a temporary perched water table. In subdivisions, commercial sites and other developed areas, this perched water table can cause serious problems of seepage, erosion, and foundation stability. A health hazard may also exist, especially in areas where septic leach lines are on or in the claypan. Three subdivisions of drainage are used in this report. They are:

Well drained - soils that have no water table within 60 inches of the surface and that have rapid to moderate permeability.

Poorly drained - soils that have a high water table during at least part of the year.

Slow permeability - soils that have clay textures throughout or are underlain by a nearly impervious claypan.

LEGEND

A—LOW POTENTIAL VOLUME CHANGE

B—MODERATE POTENTIAL VOLUME CHANGE

C—HIGH POTENTIAL VOLUME CHANGE

DEFINITION:

SHRINK-SWELL POTENTIAL IS THAT QUALITY OF A SOIL THAT DETERMINES ITS VOLUME CHANGE WITH MOISTURE CONTENT.

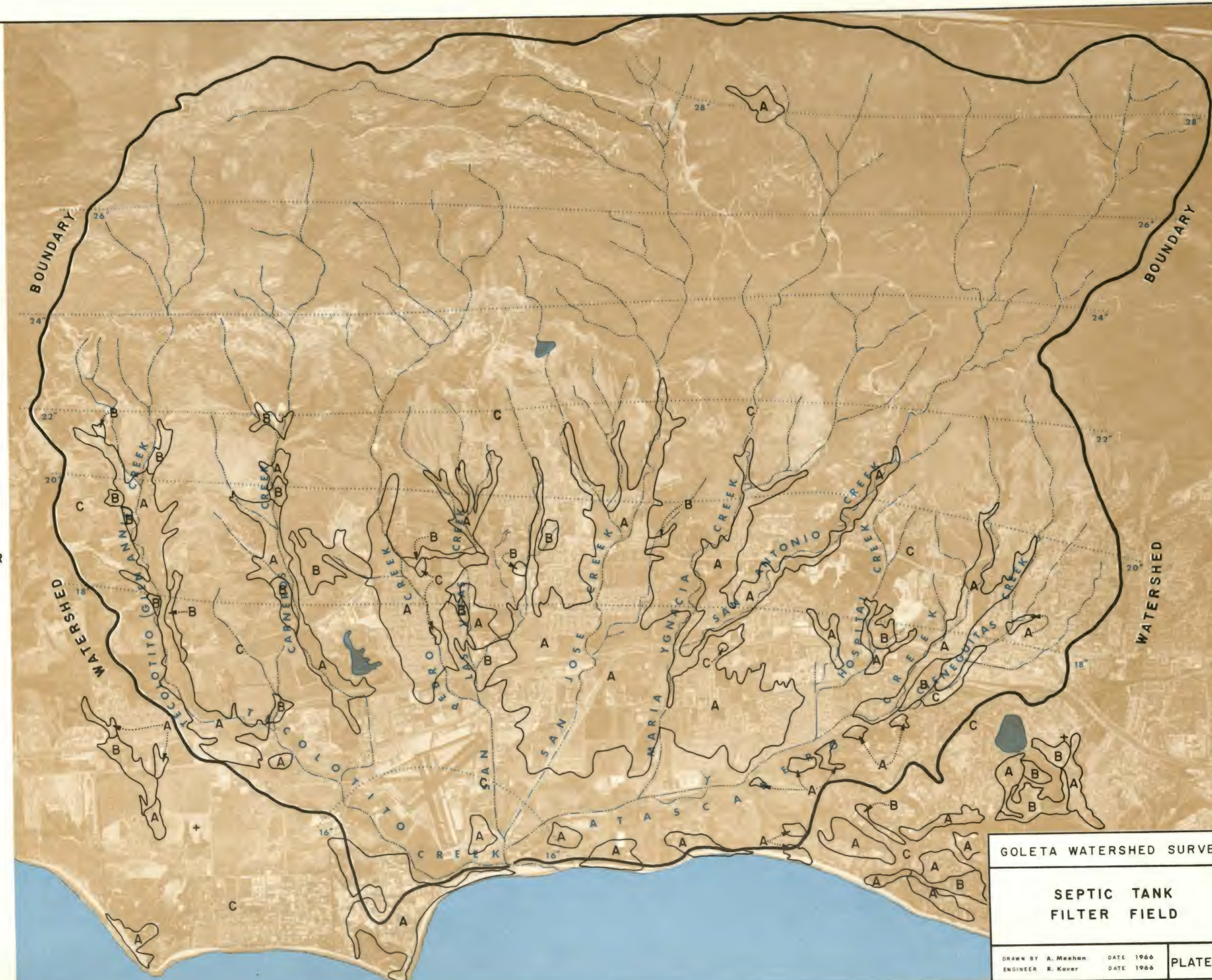
AVERAGE WATER YEAR ISOHYETS (INCHES)

CREEKS

GOLETA WATERSHED SURVEY

SHRINK AND SWELL OF SOILS

DRAWN BY A. Meehan	DATE 1966	PLATE X
ENGINEER R. Kover	DATE 1966	



LEGEND

0 2000 4000
SCALE (FEET)

A ······ SLIGHT LIMITATION FOR ABSORPTION OF SEWAGE EFFLUENT

B ······ MODERATE LIMITATION FOR ABSORPTION OF SEWAGE EFFLUENT

C ······ SEVERE LIMITATION FOR ABSORPTION OF SEWAGE EFFLUENT

AVERAGE WATER YEAR ISOHYETS (INCHES)

CREEKS

GOLETA WATERSHED SURVEY

SEPTIC TANK FILTER FIELD

DRAWN BY A. Meehan DATE 1966
ENGINEER R. Kover DATE 1966

PLATE VI

L E G E N D

0 2000 4000
SCALE (FEET)

A···· LOW TENDENCY TO SLIP

B···· MODERATE TENDENCY TO SLIP

C···· HIGH TENDENCY TO SLIP

DEFINITION:

SLIPPAGE IS THE TENDENCY FOR THE SOIL MANTLE TO SLIDE DOWN SLOPE BY THE FORCES OF GRAVITY

·············· AVERAGE WATER YEAR ISOHYETS (INCHES)

——— CREEKS

GOLETA WATERSHED SURVEY

SOIL SLIPPAGE

DRAWN BY A. Meehan DATE 1966
ENGINEER R. Kover DATE 1966

PLATE VII

0 2000 4000
SCALE (FEET)

L E G E N D

A ····· WELL DRAINED

B ····· POORLY DRAINED

C ····· SLOW PERMEABILITY

·········· AVERAGE WATER YEAR ISOHYETS (INCHES)

—·— CREEKS

GOLETA WATERSHED SURVEY

SOIL DRAINAGE

DRAWN BY A. Meehan DATE 1966
ENGINEER R. Kover DATE 1966

PLATE VIII

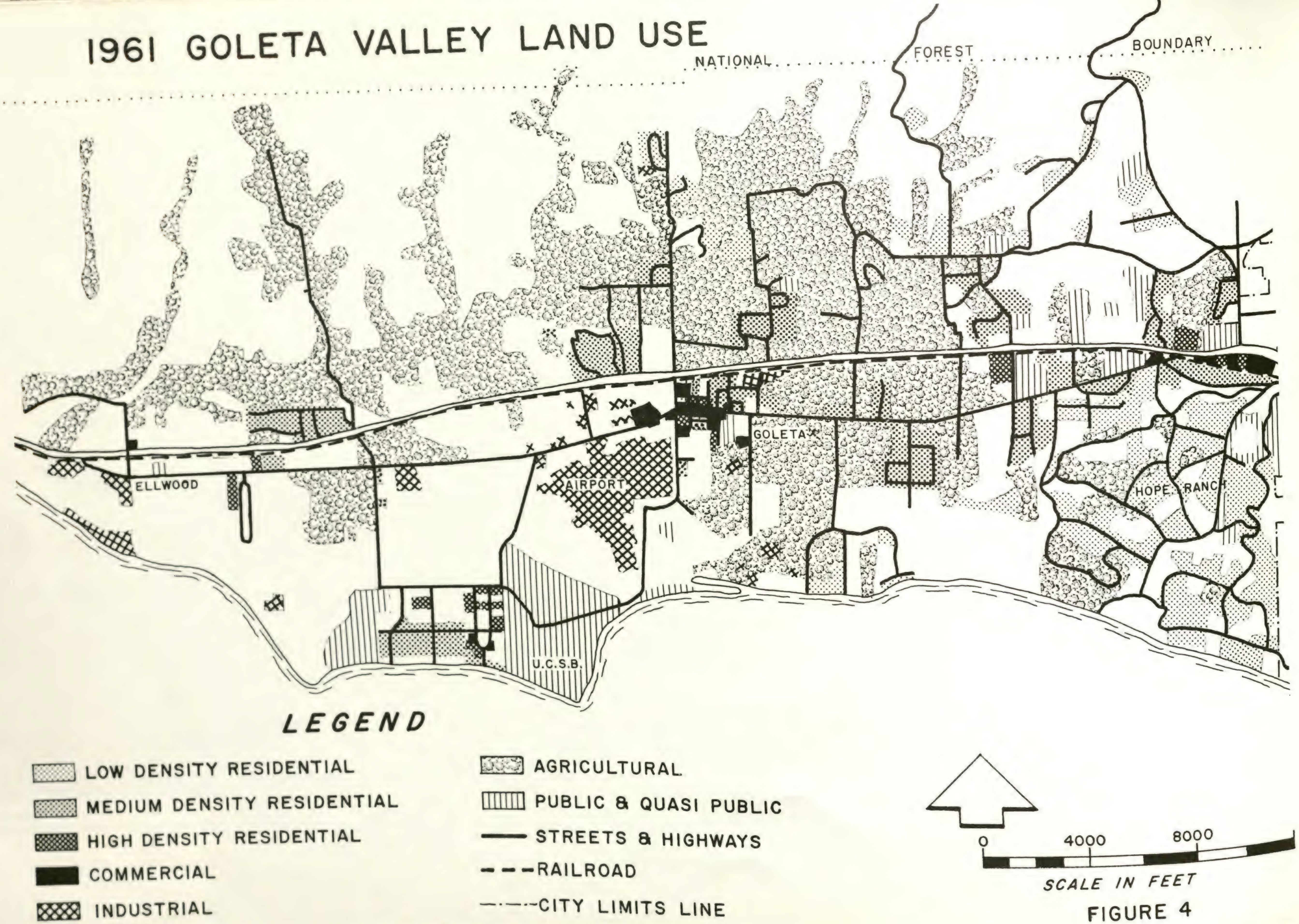

1961 GOLETA VALLEY LAND USE
NATIONAL
FOREST
BOUNDARY
ELLWOOD
AIRPORT
GOLETA
U.C.S.B.
HOPE RANCH
LEGEND
LOW DENSITY RESIDENTIAL
MEDIUM DENSITY RESIDENTIAL
HIGH DENSITY RESIDENTIAL
COMMERCIAL
INDUSTRIAL
AGRICULTURAL
PUBLIC & QUASI PUBLIC
STREETS & HIGHWAYS
RAILROAD
CITY LIMITS LINE
0
4000
8000
SCALE IN FEET

FIGURE 4

CHAPTER IV

LAND USE, ECONOMIC DEVELOPMENT AND POPULATION GROWTH

A. RECENT CONDITIONS

The scarcity of land in the narrow strip between the mountains and the sea included in the Goleta Watershed has created a situation of competitive land uses in recent years. In the early days of the Mission Fathers and the hide-and-tallow economy, ample land was available. But, with population on the increase and changing economic trends, the land is becoming increasingly scarce.

Lands of the Goleta Watershed area are divided between the upland mountainous area and the downstream valley and flood plain. The upland and mountainous areas lie generally within the Los Padres National Forest Figure 4. About a half of the Forest area is in private ownership. Downstream lands are all in private ownership excepting for public improvements.

1. 1961 LAND USE

The first comprehensive and accurate knowledge of land use within Santa Barbara County was provided thru surveys identified with water resources and general plan studies concluded in 1959 and 1961. Use of land located within the Goleta Valley is shown on Figure 4. The major land uses are summarized in Table 6 and Figure 5. These figures are for the overall Goleta area and have not been adjusted to the watershed land area.

During this period of analysis (1959-1961) the economic outlook for lemons and several other crops was not bright, so there was a strong motive to sell-out for subdivision.

In 1961 about one-half of the land in the Valley was open pastureland and unused lands. Of the developed land, about five-eights was farmed, with its principal use for orchard crops, mostly lemons.

The shift of land from farming to residential and other urban uses had been going on gradually for some years, but really began in major proportions about 1958. Several major residential developments are noted in the midst of concentrated farming areas on the accompanying map.

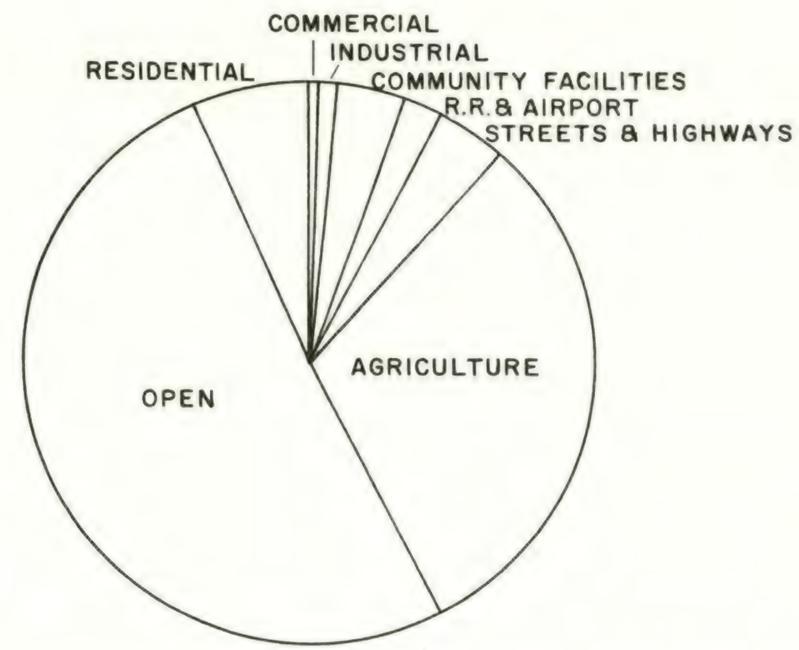
2. ECONOMIC DEVELOPMENT AND POPULATION GROWTH

The economic survey of Santa Barbara County, concluded in 1961, revealed seven major types of economic activity that support the present population. Estimates relatable to future economic activity were made available following an intensive investigation of individual sources of net export income. Net export income is that portion of total net income resulting from trade (sale of goods and services) with outside economic areas. Net export income, when related to total net income and the existing population, can serve as a basis for population projections.

Use of economic forecasts to provide population estimates must be limited to areas separate and distinct from one another. The communities located on the south coast of Santa Barbara County were considered to represent one economic area. The further analysis required to understand the socio-economic interrelationship of sub-areas such as the Goleta Valley, exceeds the scope of the 1961 survey. It was therefore necessary to make interpolations for the Goleta Valley.

The largest class of economic activity on the south coast is the retirement and wealthy resident group which is called "Property and Pensions." Although some residents of the Goleta Valley are in this class, particularly the Hope Ranch area, this is not the important factor that it is in the Santa Barbara and Montecito subdistricts.

Second in the major monetary contribution classes is tourism, or called "Visitors" in this study. Although Goleta gets some tourists, particularly because of the airport, this too is an activity more closely associated with Santa Barbara proper.



1961 PERCENT DISTRIBUTION OF LAND USE

Source : 1959 Calif. State Dept. Water Resources land use survey.
1961 County Planning Dept. land use

FIGURE 5

"Manufacturing" by the aerospace research and development firms located in the Goleta Valley is the third major source of income. This activity centered around the airport and the University of California at Santa Barbara campus, is one of the principal payroll sources in the area.

"Agriculture" produces about $13-million of new wealth for the south coast annually, about half of which is from the Goleta Valley. This economic activity, which was ranked fourth in 1961, is the only one which is projected to diminish by 1978.

Next in rank in 1961 was the University of California at Santa Barbara with a student enrollment of 4100. This major campus is located in the heart of the Valley and is probably the most important expanding economic activity in the late 1960's. Its impact on the Valley will continue as the current (1966) student population of 11,000 grows to an ultimate of 27,500.

The other major industries of "Missile Bases", the economic effect of Vandenberg Air Force Base on the south coast, and "Mining", which is mainly oil drilling in the tidelands, will continue to influence the area but at modest paces.

Table 6

1961 Land Use Survey, Goleta Valley

Use	Acreage	% Total
Residential	1,475	6.7
High Density	89	.4
Medium Density	712	3.2
Low Density	674	3.1
Commercial	98	.4
Industrial	242	1.1
Community Facilities	803	3.7
Railroad / Airport	510	2.3
Streets / Highways	888	4.0
Agriculture, cropland	6,706	30.5
Irrigated Land	5,948	27.0
Field Crop	826	3.8
Orchard	5,020	22.8
Idle	102	.4
Non-Irrigated Land	758	3.5
Field Crop	336	1.6
Orchard	88	.4
Idle	334	1.5
Open Land, including rangeland	11,305	51.3
Total	22,027	100.0%

Population change within the sub-area is dependent on the socio-economic relationship to the total area of the south coast of Santa Barbara County. The geography, topography, opportunity for employment, trade facilities, advantages for cultural exchange, etc. determine this relationship.

The nearness and availability of land for residential development make the Goleta Valley attractive to the labor force identified with the City of Santa Barbara. Space available in Santa Barbara cannot support the demand for low density residential use. Location of the University of California at Santa Barbara in the Goleta Valley has, and will, cause rapid growth of population thru the remainder of the present decade. These and the other major sources of basic income — (agriculture, manufacturing, research and development activity) will stimulate growth of retail trade and service establishments required by the resident population.

Growth in population resulting from an increase in economic activity as illustrated in Table 7, is not in complete agreement with the population projections in Table 8. The influence of changes not fully realized in the 1961 economic survey are reflected in the series of population projections. The growth and ultimate enrollment of the University of California at Santa Barbara exceeds the 1961 estimate. In addition, income related to other economic activities has been subject to some unforeseen change. But again, this study could not provide the details necessary for revising the economic data to the current situation.

B. FUTURE LAND USE

1. PROJECTED 1980 LAND USES

Information on the projected 1980 land use is contained in Figure 7 and Table 9. The ability to forecast land use requirements results from the application of knowledge relative to future economic activity and subsequent change in population. Land use types were assumed to represent a crude extension of individual characteristics in evidence between 1961 and 1966. The location of specific types of land use within the Goleta Valley would be unreliable, hence, no attempt was made to map 1980 land use.

The projected acreage totals show that roughly one-quarter of the land will be used for residences, with significant increases in other urban uses. Another quarter will be used for intensive agriculture, mainly lemons, avocados, and flower crops. About one-third will be open land, mainly used for grazing, but with scenic and open space values.

One-third of the population forecast for the Goleta Valley in 1980 will be students, employees, or dependents of students and employees at the University of California. An equal amount will be supported through employment opportunities available in the Goleta sub-area, mainly in research and development industries and the business community. The balance of the population will relate to the labor force of other sub-areas, mainly the City of Santa Barbara.

2. GENERAL PLAN FOR ULTIMATE DEVELOPMENT

In the preparation of the General Plan, the assumption was made that it should reflect the ultimate urban development of all of the Valley. Figure 8 is presented as the 1966 concept of what ultimate development might look like. Table 10 and Figure 9 give the land use acreage projections.

POPULATION TRENDS AND PROJECTIONS FOR THE SOUTH COASTAL AREAS OF SANTA BARBARA COUNTY.

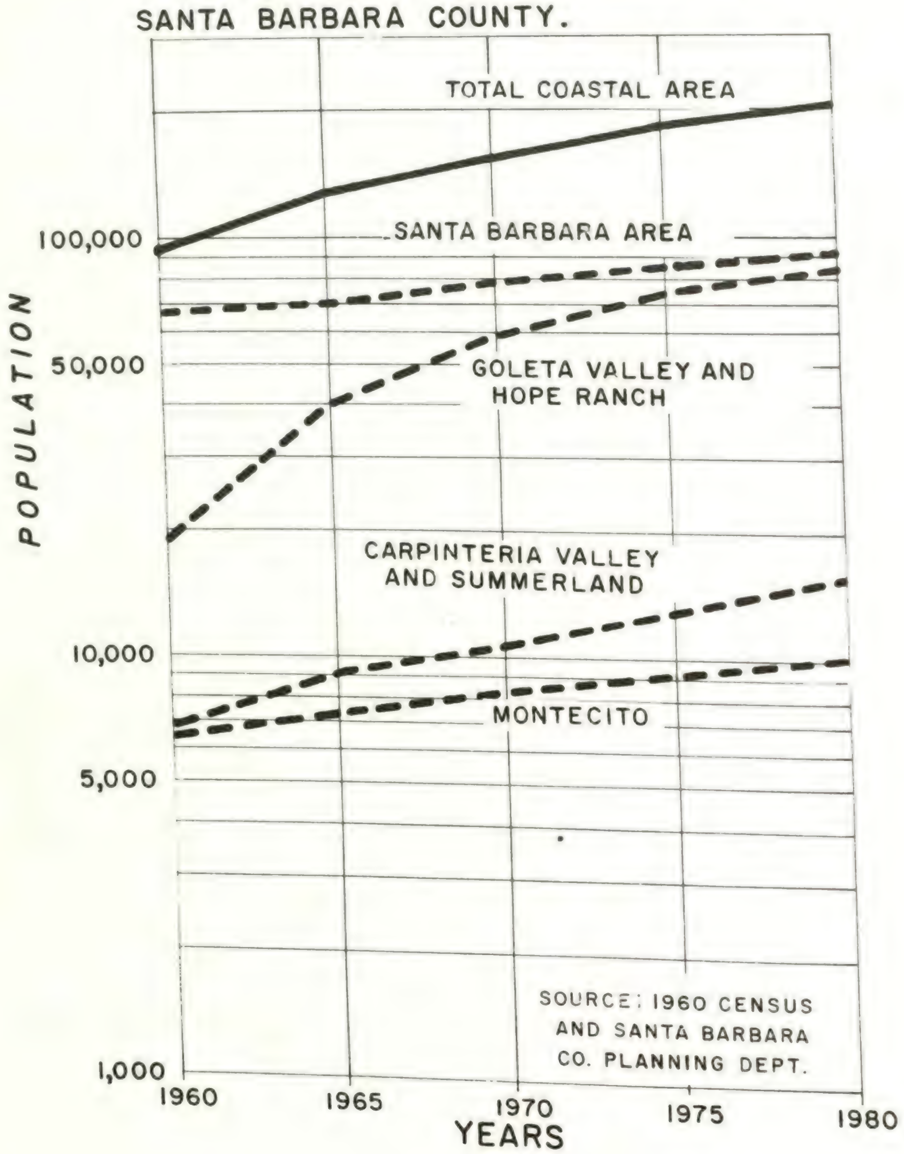


FIGURE 6

Table 7

South Coast Area Santa Barbara County

Net Export Income

Major Sources of Income		Estimated 1960 Income	Projected 1978 Income
Property & Pension	\$ Millions	29.2	53
	% Total County	87%	80%
Visitors	\$ Millions	23.3	61
	% Total County	77%	70%
Manufacturing, Res. & Develop.	\$ Millions	19.7	50
	% Total County	91%	70%
Agriculture	\$ Millions	12.7	6
	% Total County	32%	11%
University	\$ Millions	6.4	36
	% Total County	100%	98%
Missile Bases	\$ Millions	4.2	4
	% Total County	7%	5%
Mining	\$ Millions	2.3	3
	% Total County	30%	25%
Other	\$ Millions	7.6	14
	% Total County	84%	68%
TOTAL	\$ Millions	105.4	227

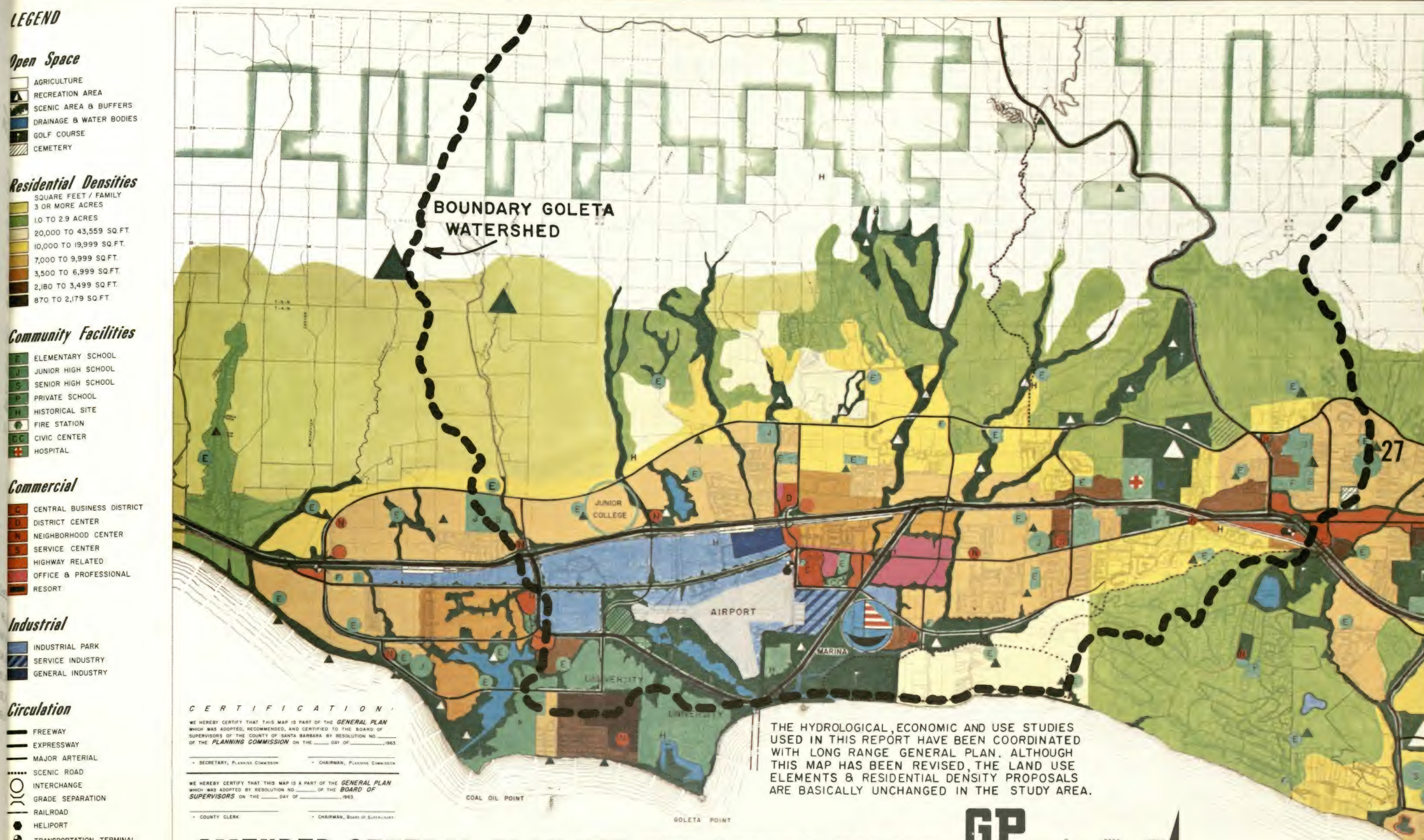
Table 8

Population Estimates for Santa Barbara County

County Planning Department

Date*	Goleta Valley	South Coast	County
1950 Census	8,100	63,305	98,22[illegible]
1960 Census	19,026	93,255	168,96[illegible]
1966 Estimate	44,375	134,125	249,51[illegible]
1970 Projection	59,400	157,500	291,0[illegible]
1975 Projection	74,400	182,700	330,3[illegible]
1980 Projection	94,400	214,400	376,4[illegible]

*all are on basis of April 1 of year noted.



AMENDED GENERAL PLAN FOR THE GOLETA VALLEY

FIGURE 8

The dominant land uses projected are residential and greatly exceed the land needed by the 1980 population forecast. It is difficult to say when this ultimate development might take place, perhaps after the turn of the century.

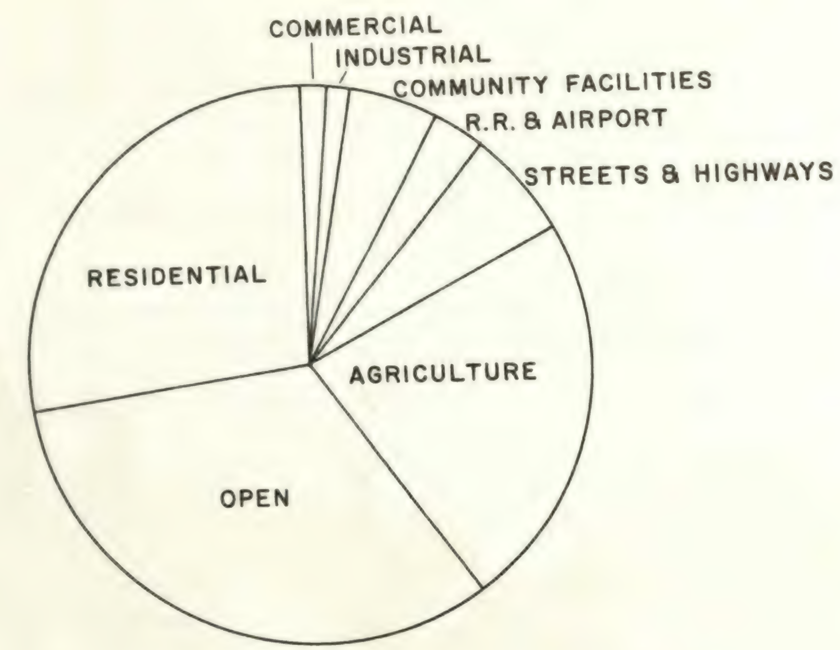
The land use recommendations in the General Plan should be revised at regular intervals. A land use pattern may exist in an area of moderate to heavy population growth without significant change for three to seven years. The longevity of a plan is related to present knowledge of and ability to forecast socio-economic change.

Recent developments in the Goleta area, chiefly of an economic nature indicate that the urbanization of the region may not proceed as rapidly nor to the ultimate extent as visualized for the Goleta region in the General Plan. A marked slowdown in home construction, a dearth of capital, high interest rates, a trend toward high rise developments, and a tendency to preserve farm lands solely for agricultural purposes through contractual arrangements with the county government are some of the factors responsible for the change in trend. It is suggested accordingly that a revision of the General Plan be undertaken at an early date in order to embody current thinking on the growth pattern for the Goleta area.

Table 9

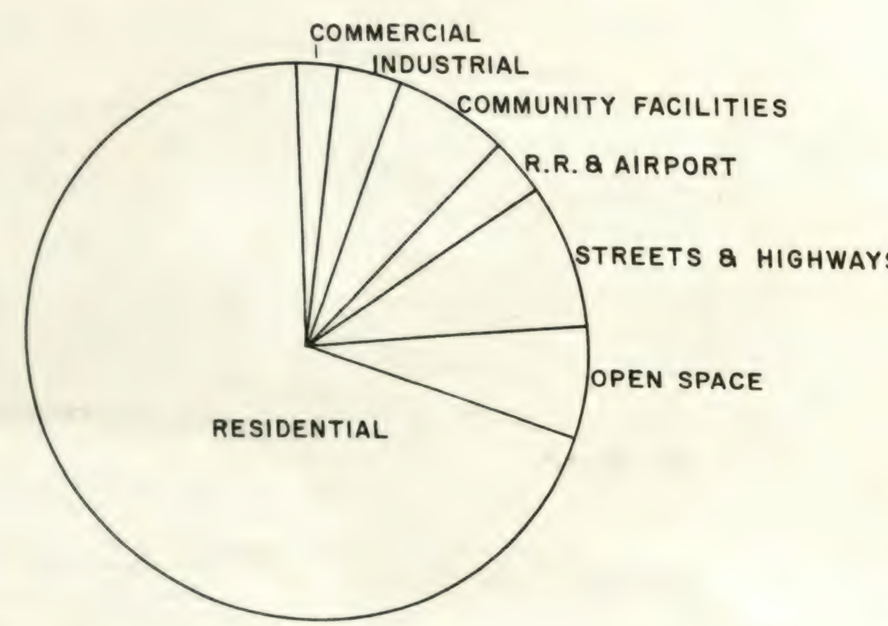
1980 Land Use Projection, Goleta Valley

Use		Acreage		% Total
Residential		6,088		27.6
High Density	311		1.4	
Medium Density	3,313		15.0	
Low Density	2,464		11.2	
Commercial		328		1.5
Industrial		340		1.6
Community Facilities		1,079		4.9
Railroad / Airport		647		2.9
Streets / Highways		1,313		6.0
Agriculture, cropland	5,030		22.8	
Irrigated Land		4,500		20.4
Field Crop	450		2.0	
Orchard	4,000		18.2	
Idle	50		.2	
Non-Irrigated Land		530		2.4
Field Crop	280		1.3	
Orchard	50		.2	
Idle	200		.9	
Open Land, including rangeland		7,202		32.7
TOTAL		22,027		100.0%



1980 PERCENT DISTRIBUTION OF LAND USE

Source: County Planning Dept. projection
FIGURE 7



GENERAL PLAN PERCENT DISTRIBUTION LAND USE
FIGURE 9

Table 10

Land Use, Goleta Valley General Plan

Use		Acreage		% Total
Residential		15,242		69.2
High Density	415		1.9	
Medium Density	4,970		22.6	
Low Density	9,857		44.7	
Commercial		491		2.2
Industrial		1,021		4.7
Community Facilities		1,438		6.5
Railroad / Airport		647		2.9
Streets / Highways		1,751		8.0
Agriculture, Cropland	0		0	0
Irrigated Land		0	0	
Field Crop	0		0	
Orchard	0		0	
Idle	0			0
Non-Irrigated Land		0	0	
Field Crop	0		0	
Orchard	0		0	
Idle	0			
Open Land, including rangeland		1,437		6.5
TOTAL		22,027		100.0%

CHAPTER V

HYDROLOGY AND FLOOD CONTROL

A. HYDROLOGY

1. INTRODUCTION

Hydrology has been defined as "The science that treats the waters of the Earth, their occurrence, circulation, and distribution, their chemical and physical properties, and their reaction with their environment, including their relation to living things." It may be seen that hydrology is a very broad field involving many disciplines. It is believed that classifying hydrology solely as a science is not correct because of the many variables which have not been related and the infinite number of patterns in which nature may cause them to occur. Man has not yet defined universal laws which enable him to state with authority how much rain will occur next month, how much snow will melt in February or how long it takes a drop of water to flow from the crest of the Santa Ynez Mountains to the Pacific Ocean. Hydrology in the foreseeable future will continue to be an art and a science, with judgement and experience not being wholly replaced by mathematical formulae.

The scope of this Survey embraces three elements of hydrology, namely precipitation, surface water, and ground water. Ground water is the subject of a separate chapter. This Chapter is concerned primarily with precipitation and surface waters.

Surface water studies have two main areas of emphasis:

1. Water supply surveys which are concerned with the total volume of flow during a year or series of years together with enough information on its distribution to insure that a supply will always be available. Also, the quality of the water is of importance to be certain that it is suitable for the intended uses.

2. Flood control studies which try to determine the amount and frequencies of flood flows so that economic studies may be made and control works properly designed.

These two areas are normally closely related, but in the Goleta Watershed surface water supplies are not of great importance because of the ephemeral flow in the streams and the paucity of suitable damsites. Hence stress will be placed on precipitation and flood control hydrology.

This introduction is followed by a general discussion of hydrographs and frequencies. Specific data for the Goleta Watershed is then presented, discussed, and analyzed.

2. HYDROGRAPHS

A graph of rate of flow as the ordinate plotted against time as the abcissa is called a hydrograph. Typical hydrographs are shown in Figure 10. A hydrograph gives a complete picture of flow in a stream. The area under the hydrograph is the total volume of runoff. The highest point of the curve is the maximum rate of flow, called peak flow. Hydrographs are needed for the design of reservoirs including flood detention structures, hydro-electric and water supply studies, duration of flooding calculations, and other engineering where the total volume and/or time distribution of flow are needed. The peak flow is sufficient for the analysis and design of some channels, bridge openings, culverts and storm drains. It is much easier to estimate the peak flow than to calculate an entire hydrograph, so many flood estimates are based on peak flow calculations.

Hydrographs are affected by many factors, including shape and size of the watershed, amount of precipitation, temporal and areal distribution of precipitation, snow pack on the watershed, saturation of the soil, permeability of the soil, vegetative cover and urban development on the watershed, the nature of the terrain, the smoothness of the channels, the inflow of groundwater into the stream, and numerous other factors. Hydrograph "A" in Figure 10 shows how runoff might occur from a long storm on a porous watershed with rolling terrain and of medium size, say 15,000 acres. The peak of the hydrograph is broad and rounded, indicating a fairly slow runoff. The base of the hydrograph is long because a large percentage of the runoff comes from ground-water flow. Hydrograph "B" has a fairly sharp, high peak which is typical of steep, fairly small watersheds of around 3500 acres, such as those in the Goleta Watershed. The rise is rapid because of the rugged terrain and the base is narrow because a large portion of the intense rainfall runs off directly on the surface. The groundwater contribution is low. Hydrograph "C" has a vertical rising limb, a very sharp, high peak, and a short base. This type of event is often referred to as a "flash flood." Such a hydrograph can occur after a brief, intense rain on a steep burned watershed. The instantaneous rise can be accounted for by the breaking of natural dams in canyons formed by debris jams and slides. This phenomenon was observed in two Goleta Watersheds on November 9, 1964, following the Coyote Fire. Hydrograph "C" has the highest peak flow and the smallest total volume of runoff, while hydrograph "A" has the lowest peak but the greatest total volume of the three representative curves shown.

The ideal, indeed the only, way to obtain the true hydrograph of specified frequency for a given stream is to have accurate stream flow records for several hundred years from a watershed which has not changed characteristics, such as urban development replacing agriculture. With such records, the hydrologist needs no data on rainfall, soil porosity, or any of the other factors which influence runoff because the recorded hydrographs account for all of them. Such records exist for the Nile and some rivers of Europe, but certainly are not available for California streams. It therefore becomes necessary to look for means of synthesizing hydrographs.

Precipitation records in California are available for much longer periods of time than streamflow records, and though runoff does not vary directly with rainfall, there is some correlation. It is logical to try and determine this correlation and, using statistical analyses of rainfall data, determine the probable flows for given frequencies. Methods for calculating hydrographs and peak flows will be discussed later in this chapter.

3. FREQUENCY

Frequency refers to the probability of an event occurring, and it is customary in hydrologic calculations to speak in terms of "percent chance" or "return period". A 1% flood has one chance in one hundred of occurring in a given year, or a return period of 100 years, on the average. It is possible for the so-called 100 year flood to occur twice in one year, so the percent chance designation is gaining favor among engineers to avoid giving the impression that the 100 year flood is 100 years in the future and of no concern to the present generation.

The frequency of floods is important to the engineer and economist concerned with flood control and drainage works. It may not be economical to design an orchard drainage system for a flood in excess of 10% frequency, while a major dam, such as Cachuma, must have a spillway capable of safely passing the maximum probable flood, which may have a frequency of 0.1% or 0.01%. Main channels and bridges in the Goleta Watershed are generally designed for a 1% flood if under County and/or Flood Control District jurisdiction. The Corps of Engineers usually designs for what is called the Standard Project Flood, which has a frequency of about 0.3% in the study area. Santa Barbara County streets are designed to carry a 10% runoff within the curbs. Storm drain systems draining streets are designed for a 4% flood unless the street has a low point, or sump, where water in excess of a 4% flood would inundate buildings if not drained away, in which case a design frequency of 1% or 2% is used.

Using the principles of statistics, it is possible to calculate the percent chance of a flood of a given frequency occurring in a given period of years. Figure 11 enables the reader to determine this graphically. For instance, a 1% flood has one chance in ten of occurring in a ten year period, four chances in ten of occurring in a fifty year period, and so forth.

Rainfall frequencies are similar in concept to flood frequencies. The duration of rainfall must be specified, and usually ranges from 5 minutes to the water year. The frequency of rainfall is especially important to the farmer who "dry farms", and to the engineer for reasons previously mentioned.

Methods of calculating frequencies from observed data are discussed in this Chapter under "Analysis of Data".

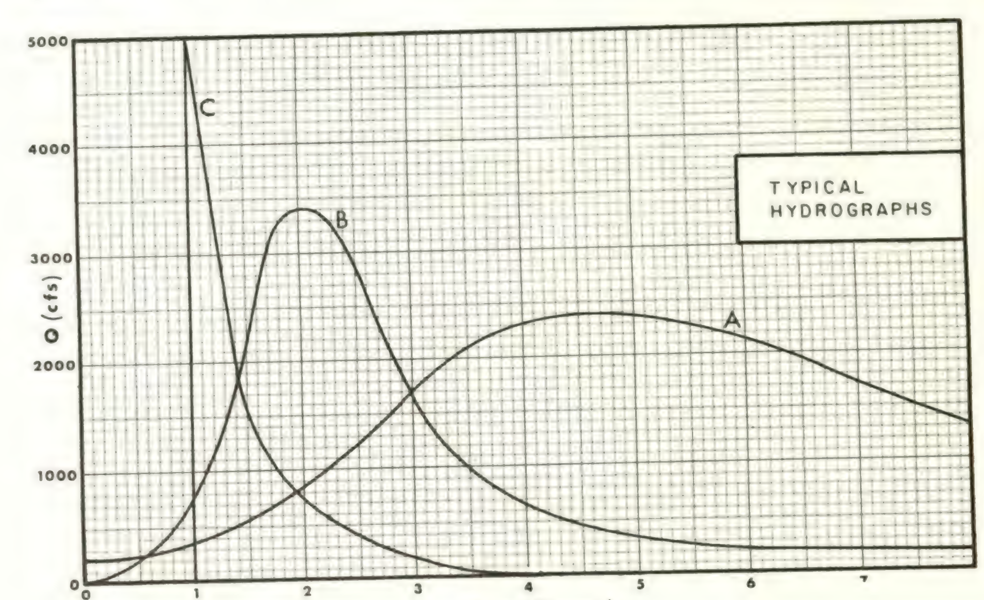


FIGURE 10

TABLE II
WATER YEAR PRECIPITATION TOTALS
(in inches)

Water Year	Santa Barbara	Pinecrest	San Marcos Summit
1867-68	25.19	-	-
1868-69	15.77	-	-
1869-70	10.27	-	-
1870-71	8.91	-	-
1871-72	14.94	-	-
1872-73	10.52	-	-
1873-74	14.44	-	-
1874-75	18.71	-	-
1875-76	23.07	-	-
1876-77	4.49	-	-
1877-78	28.51	-	-
1878-79	13.61	-	-
1879-80	25.64	-	-
1880-81	15.23	-	-
1881-82	14.27	-	-
1882-83	13.41	-	-
1883-84	34.47	-	-
1884-85	13.29	-	-
1885-86	24.24	-	-
1886-87	12.96	-	-
1887-88	21.73	-	-
1888-89	21.04	-	-
1889-90	32.47	-	-
1890-91	17.31	-	-
1891-92	10.76	-	-
1892-93	27.02	-	-
1893-94	7.02	-	-
1894-95	16.34	-	-
1895-96	13.32	-	-
1896-97	18.50	-	-
1897-98	4.57	10.13*	-
1898-99	12.35	17.52	17.25
1899-1900	12.65	17.58	20.13
1900-01	15.40	20.80	31.62
1901-02	14.21	22.63	20.37
1902-03	20.74	14.73	31.87
1903-04	11.58	30.84	29.68
1904-05	29.64	29.27	47.38
1905-06	22.68	42.36	37.31
1906-07	27.74	36.92	44.52

Water Year	Santa Barbara	Pinecrest	San Marcos Summit	Goleta Lemon Co.	Santa Barbara Airport
1907-08	19.00	21.51	29.92	-	-
1908-09	35.82	51.03	56.19	-	-
1909-10	19.61	14.71	31.83	-	-
1910-11	31.94	44.14	55.46	-	-
1911-12	16.35	18.13	22.92	-	-
1912-13	12.78	23.93	18.29	-	-
1913-14	31.52	40.37	53.94	-	-
1914-15	21.46	25.55	36.71	-	-
1915-16	25.88	-	-	-	-
1916-17	22.56	-	-	-	-
1917-18	21.68	-	-	-	-
1918-19	14.16	-	-	-	-
1919-20	14.68	-	-	-	-
1920-21	14.31	-	-	-	-
1921-22	19.25	-	-	-	-
1922-23	17.24	-	28.63	-	-
1923-24	6.36	-	11.13	-	-
1924-25	11.67	-	22.24	-	-
1925-26	16.93	-	31.14	-	-
1926-27	22.73	-	40.52	-	-
1927-28	13.48	-	21.43	-	-
1928-29	15.19	-	28.23	-	-
1929-30	13.91	-	20.23	-	-
1930-31	14.39	-	20.97	-	-
1931-32	22.14	-	40.26	-	-
1932-33	8.64	-	15.34	-	-
1933-34	12.43	-	27.73	-	-
1934-35	21.20	-	35.45	-	-
1935-36	16.57	-	29.44	-	-
1936-37	25.38	-	39.25	22.76	-
1937-38	26.10	-	46.70	22.81	-
1938-39	13.40	-	21.43	14.37	-
1939-40	14.94	-	23.53	15.46	-
1940-41	45.21	-	68.15	45.76	-
1941-42	12.87	-	26.26	14.85	11.95

Water Year	Santa Barbara	Pinecrest	San Marcos Summit (Marshall)	San Marcos Summit (Tenney)	Goleta Lemon Co.	Santa Barbara Airport	La Patera Rancho	Dos Pueblos Canyon	Goleta County Water Dist.	San Marcos Trout Club	La Cumbre Mutual Water	Santa Barbara Botanic Gardens	Santa Barbara T.V. Peak
1942-43	24.57	-	30.38	37.74	21.06	19.80	21.06	-	-	-	-	-	-
1943-44	17.95	-	29.09	34.05	19.27	15.18	17.96	-	-	-	-	-	-
1944-45	11.36	-	22.64	26.70	15.87	13.59	15.78	-	-	-	-	-	-
1945-46	11.54	-	25.06	26.81	14.03	12.95	13.86	-	-	17.32	-	16.28	-
1946-47	14.10	-	18.68	25.74	11.34	9.66	13.82	-	-	16.93	-	16.83	-
1947-48	9.25	-	12.65	15.70	7.87	7.73	8.45	-	-	11.68	7.91	10.64	-
1948-49	11.34	-	19.46	23.58	10.24	9.57	10.99	-	-	18.94	11.47	14.67	-
1949-50	13.61	-	15.94	21.46	13.20*	13.52	14.93	-	-	16.86	12.42	15.09	-
1950-51	11.24	-	13.92	17.05	10.90*	10.37	10.90	-	-	15.60	11.58	10.66	-
1951-52	31.23	-	46.31	50.93	30.32*	25.38	26.75	-	-	43.31	29.33	38.62	-
1952-53	13.44	-	18.40	21.05	12.71	12.43	14.15	-	-	17.28	13.61	14.70	-
1953-54	15.44	-	21.40	23.88	14.21	14.17	15.12	18.64	-	17.14	14.44	18.67	-
1954-55	16.92	-	23.47	26.15	16.36	14.84	17.09	21.55	17.54	20.58	17.02	18.14	-
1955-56	19.84	-	31.16	35.19	19.49	17.84	20.87	27.78	17.95	25.52	21.87	23.43	40.41
1956-57	13.86	-	21.43	24.83	12.72	11.87	13.48	16.62	12.00*	23.88	14.05	18.03	24.91
1957-58	31.94	-	49.36	49.98	28.60	26.16	29.52	38.71	28.76	42.02	31.75	36.19	39.44
1958-59	9.06	-	18.60	18.61	8.37	7.45	9.19	14.29	8.10	16.03	8.28	12.16	23.07
1959-60	10.81	-	14.60	18.41	11.59	11.73	11.94	14.87	10.73	17.72	12.23	12.90*	19.39
1960-61	9.94	-	12.48	14.89	8.43	7.95	8.81	12.83	6.54	13.53	8.07	11.44	19.69
1961-62	26.12	-	38.56	39.46	22.54	20.96	22.89	31.30	25.44	38.34	25.75	34.29	33.51
1962-63	15.56	-	19.50	17.16	16.21	14.99	16.25	19.05	14.77	21.63	15.40	17.80	26.53
1963-64	10.19	-	17.88	16.18	10.60	9.23	10.36	12.56	9.16	16.33	10.23	12.59	19.82
1964-65	18.53	-	-	27.94	19.16	18.04	18.78	22.13	18.90**	26.01	18.69	21.34*	23.73
1965-66	14.35	-	-	34.26	16.03	13.49	16.56	23.69	16.60	25.77	16.23	19.19	20.93
1966-67	24.88	-	-	48.72	23.54	21.24	-	31.19	22.13	39.74	23.43	30.48	42.39
Years of Record	100		59	25	31	26	24	14	13	22	20	22	12
Unadjusted Mean	17.78	27.77	28.91	27.86	17.14	14.35	15.90	21.80	16.04	22.83	16.19	19.28	30.34
Adjusted Long Term Mean	17.78	23.65	28.80	30.40	17.25	15.92	17.78	22.94	16.71	25.25	17.60	24.18	31.65

*Prorated from Santa Barbara Gage
**Prorated from Santa Barbara Airport

Photo 16. Flooding of Santa Barbara Airport, January 24,1967. Photo was taken 2 hours after the peak of the flood.

4. HYDROLOGIC RECORDS

Hydrologic data of primary concern to surface water studies are streamflow and rainfall records. Records of ground water levels, temperatures, cloudiness, wind intensity and direction are covered in other chapters of this report.

Rainfall Records. Rainfall records consist of data on the amount of rain which falls in a specified time interval at specific locations. The quantity of rain is measured as a depth in inches. The time period varies from annual totals for storage gages in the back country which are read once a year to continuour records from recording gages.

Rain gages fall into two general categories, recording and non-recording. Within each category there are many types. The standard non-recording and recording gages have 8 inch diameter circular funnels which collect the rainfall. In the standard non-recording gage, the water is collected in a tube with an area 1/10 that of the funnel and the amount of rain is read to the closest 0.01 inch with a dipstick. Other types of non-recording gages in common use in Santa Barbara County include plastic wedge gages with a 2½ inch square opening, miniature plastic standard gages with a 4 inch diameter funnel, and plastic tubes with a 1 inch aluminum funnel. Non-recording rain gages in populated areas are usually read daily by observers. There is no standard time for reading gages, but the Santa Barbara County Flood Control District encourages observers to read gages as close to 8:00 A.M. as possible. Unless gages are read at close to the same time, it is impossible to compare results for short period storms between various stations.

Photo 17. Two recording raingages installed at San Marcos Pass. The near gage records on binary digital punched tape and has telephonic interrogation. The far gage has a pen and chart recording mechanism. Both gages are equipped with wind shields.

Recording gages have various mechanisms for making continuous records of rainfall received. The most accurate types catch the water from the funnel in a bucket which rests on a weighing scale. The scale reading is recorded by a pen on a clock-driven chart or is punched in binary form on a two inch tape. The binary tape data can be reduced to printed form by automatic machines, which results in overall economy even though the punched tape gages cost three times as much as the pen and chart gages. The U.S. Wather Bureau is changing its recording rain gage stations to the punched tape type and as a result a number of pen and chart gages were made available for the Goleta Watershed Survey and have been placed at strategic locations in the study area.

The amount of rain caught by a gage depends a great deal on the exposure, or the location relative to the surroundings, of the gage. Ideally, there should be no trees or structures above a cone 30° from the horizontal plane of the gage. Strong winds often blow rain by gages and shielding is sometimes necessary. All types of gages discussed previously will receive approximately the same amount of rainfall when there is no wind, but local observations indicate a wide discrepancy between readings from gages of different types only a few feet apart when there is appreciable wind. The standard 8 inch gage appears to catch the greatest depth of rainfall under such conditions, with the plastic wedge gages reading 10% to 20% less and the 4 inch round plastic gages reading 20% to 30% less on the average.

Available Rain Gage Records. The United States Weather Bureau is the federal agency charged with collecting rainfall data. It has published data for several stations in Santa Barbara County for over sixty years. Non-recording Weather Bureau gages in the vicinity of the Goleta Watershed include: Santa Barbara, from 1868; Pinecrest (above the Botanical Gardens), 1898-1916; Santa Barbara Airport, from 1942; and T.V. Peak, from 1956. A recording gage has been maintained at Santa Barbara from May 13, 1940.

These Weather Bureau stations form a base for beginning a study of rainfall in the Goleta Watershed, but are not adequate to define rainfall distribution in a region where orographic influence is as great as in the Santa Ynez Mountains. Official records are especially scanty for the mountain slopes and crests. One of the first items undertaken under this Survey was to supplement the existing raingage net with additional gages, especially of the recording type. Also, efforts were made to locate records from private gages in the vicinity of the study area. Records were obtained from many sources, including data from San Marcos Pass from 1898 to 1916 and from 1921 to date.

Annual rainfall by water year for each known station in or near the Goleta Basin with a significant duration of records is given in Table 11. Selected maximum rainfall totals for various stations and durations are given in Table 12. Note that the maximum daily rainfall is less than the maximum 24 hour rainfall. The reason for this is that non-recording gages are usually read once daily and the reading may occur in the middle of a heavy storm, resulting in the storm being recorded on two days even though its duration might be only a few hours. Statistical and empirical studies indicate that hourly, daily and calendar monthly totals should be multiplied by 1.13 to obtain most probable 60 minute, 24 hour and 30 day amounts respectively. The data in the table are "raw" and have not been so corrected.

Analysis of Rainfall Records. Because of the 99 years of records available, the Santa Barbara raingage was selected as the base station to which all other gages were related. It was necessary to determine if a consistent correlation existed between gages. This was determined by plotting monthly rainfall for the station being investigated against the Santa Barbara gage readings for the same periods. The points so plotted tended towards a straight line which indicated that a consistent relationship exists. A straight line was fitted to the points by the least squares procedure, and the slope of the line is the factor by which the Santa Barbara rainfall is multiplied to get the amount at the other station. Figure 12 shows this procedure for the San Marcos Pass gage. It may be seen that rainfall at the Pass averages 2.01 inches plus 148% of the rainfall at Santa Barbara.

Average monthly and yearly rainfalls for stations with short periods of record should not be directly compared with like amounts from long term stations because the short record station averages may be based on an untypical dry or wet period. Therefore, the average amounts for various stations printed in Table 1 were adjusted to be consistent with the Santa Barbara gage. This was accomplished for the periods of records available by determining the ratios to the long term averages of the same periods of records at Santa Barbara and multiplying the short term averages by these ratios as shown in Table 11. Average annual isohyetal lines are shown in blue on several Plates.

A frequency histogram of monthly rainfall at Santa Barbara for one inch depth intervals was prepared and is reproduced in Figure 13. The monthly mean and median amounts were calculated and are also shown in Figure 13. It is instructive to note the significant difference between these two figures for the wet months. Also notice that the most frequently observed monthly rainfall is from zero to one inch, even for January and February, which have the highest average amounts.

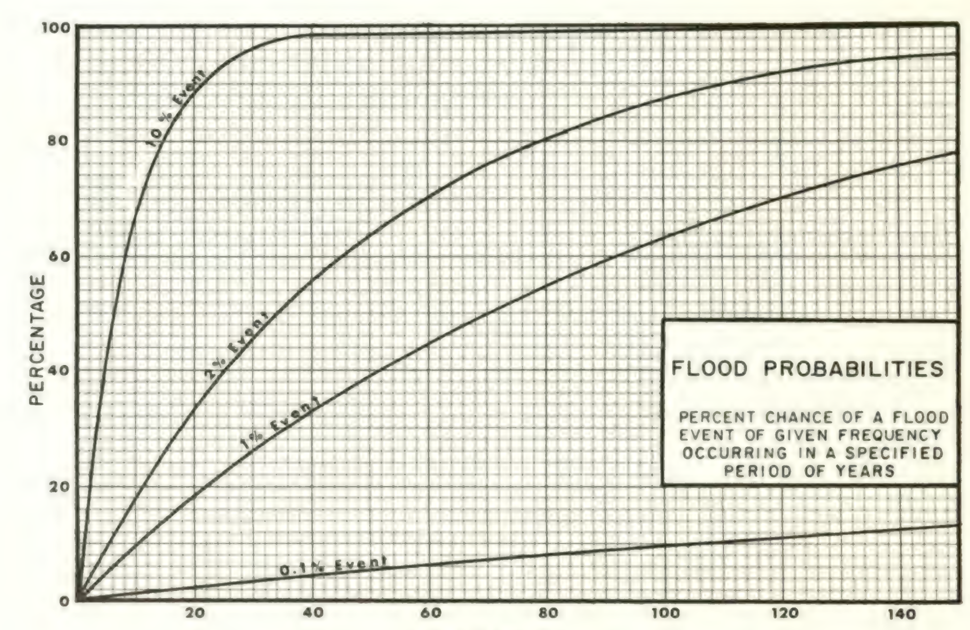


FIGURE 11

Frequency analyses for rainfalls of various durations and stations were prepared using the procedures outlined in Weather Bureau Technical Paper 40, supplemented by lecture notes from a course in the statistics of extreme hydrologic events given by Prof. E.J. Gumbel at the International Course in Hydraulic Engin-erring in Holland. The procedure for analyzing 6 hour rainfall amounts from the Santa Barbara recording gage is given as an example. An annual series was prepared which consisted of the highest rainfall amounts for consecutive six hour periods in each season (September-August) of record ranked in order of magnitude, as shown in Table 13. Plotting positions were calculated and the points plotted on Gumbel's probability paper. A straight line was fitted through the plotted points by the Gumbel method, as shown in Figure 14. From this line, 6 hour rainfall amounts of various frequencies may readily be determined. As a check, the same data was analyzed using Foster's method and a Log-Normal plot with plotting positions determined by the formula $\frac{100m}{n+1}$. The results are given in Table 14. The agreement of results from the different methods is quite good.

Table 2 gives the results of frequency analyses of seasonal precipitation for 8 stations in and near the study area. The results are expressed in columns headed by the percent chance of receiving less than the indicated amounts. The column headings may easily be converted to percent chance of the listed amounts occurring in a given season by subtracting the given percentages from 100%.

Figure 15 is a plot of seasonal (September-August) precipitation versus gage elevation for various stations on the coastal and inland slopes of the Santa Ynez Mountains. This graph was prepared to see if there are relationships between rainfall and elevation regardless of frequency. The results indicate there are. They may be expressed in simple empirical equations of the form P = K (E + C), where P is the seasonal precipitation in inches, E the elevation above sea level in feet, C a constant which is 3500 for the coastal slopes and 5400 for the inland slopes, and K a variable factor depending on frequency and location determined from observed records. Table 15 gives the equations for various frequencies. These equations are valid only up to E = 2500 feet. Precipitation above 2500 feet is almost constant on both slopes for a given frequency. The precipitation-elevation relationships are based on data from the area embracing T.V. Peak, Cachuma Dam, Summerland, and Juncal Dam and should not be applied to the interior mountains or other areas.

Figure 16 presents the results of frequency analyses of the Santa Barbara and San Marcos Pass raingage data for durations up to 12 months in the form of Depth-Duration — Frequency Curves for the 1% and 10% events. Again, the 12 month period is from September through August. The time scale has been designed to make the plot of precipitation of a given frequency for any duration linear. Plots for other stations or frequencies in the study area may be easily constructed by determining one point and drawing a line through it parallel to the plotted lines.

Intensity-Duration curves may be prepared by dividing the total rainfall amounts by the durations. Empirical equations may be written to express the intensity. For instance: the average intensities in the study area for durations up to 24 hours are expressed by:

$$i = 7.75 \frac{P_{60}}{t^{0.5}}$$

where i is the intensity in inches per hour, t the duration in minutes and P_{60} is the 60 minute rainfall, which may be obtained from Figure 17. Intensity-Duration curves are frequently used by engineers for storm drain design.

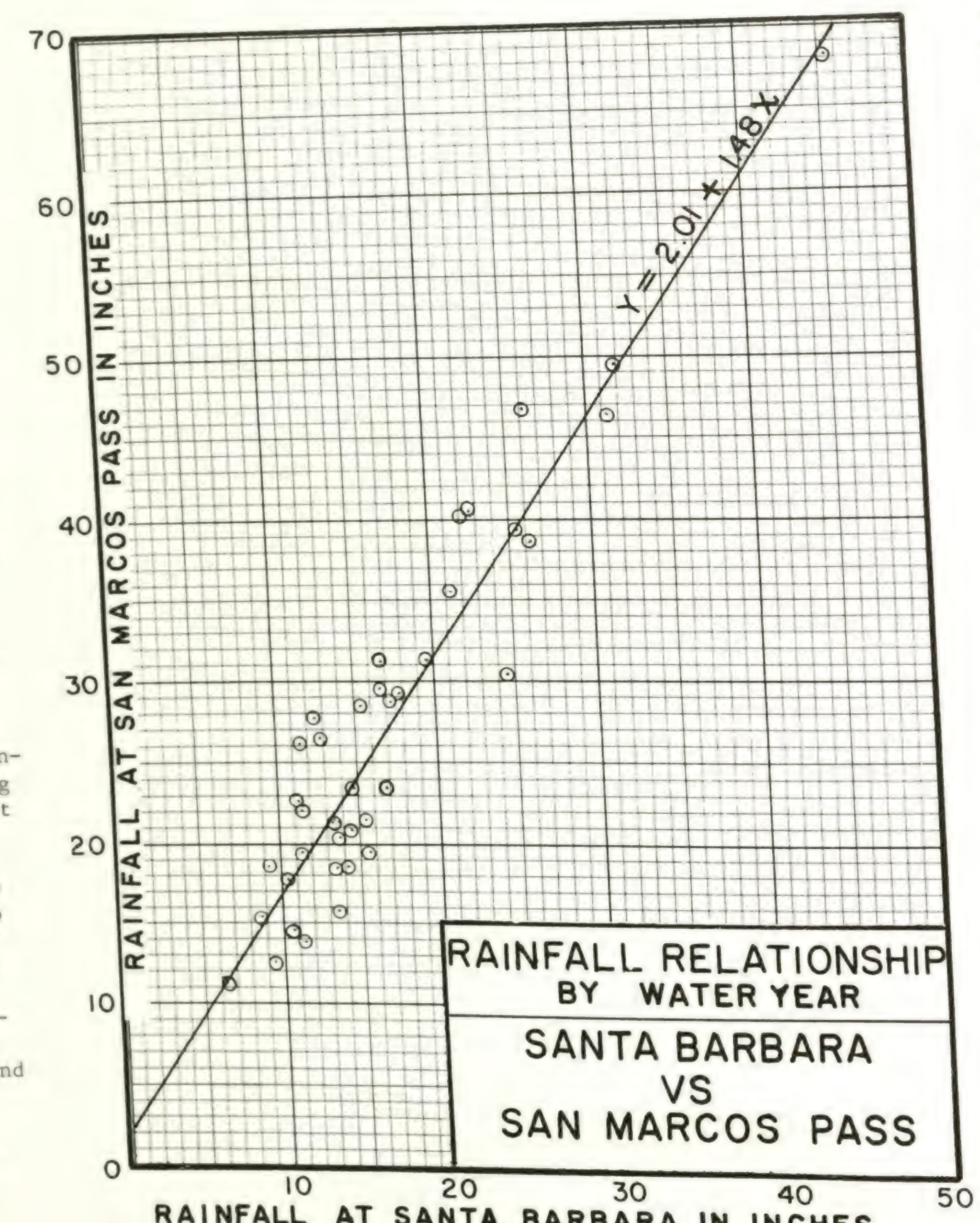


FIGURE 12

Rainfall records were examined to see if historical floods could be determined from precipitation data. There appears to be no positive correlation between rainfall totals and floods, especially for data from non-recording gages. Even hourly amounts from recording gages do not always supply a clue, as witnessed by the fact that published records for November 9, 1964, give no indication that there was sufficient rainfall to cause the severe floods which occurred. The 1927 floods in Montecito were not detected from the daily rainfall amounts and were learned of only by a chance conversation with an old time resident.

Hourly records, including those of the Weather Bureau, City of Santa Barbara, Dos Pueblos Ranch, North American Weather Consultants, and Flood Control District, were studied for known floods to determine the duration of excessive, flood producing rainfall. In every case, the heavy precipitation occurred in six hours or less. This confirms the use of a six hour storm for design purposes by the Soil Conservation Service and other agencies. It was decided to use the six hour storm in developing hydrographs for this Survey. The most probable temporal distribution with the six hours had to be determined, as it greatly affects the amount of runoff and the shape of the runoff hydrograph. The standardized curves used by the Soil Conservation Service do not apply to the study area, as they attribute too large a percentage of the total six hour precipitation to the peak hour. As the investigation showed that the peak intensities are likely to occur in the third and fourth hours, a distribution similar to the Soil Conservation Service "C" curve was selected and is shown in Figure 18. Six hour rainfall isohyetal lines for the 1% frequency were determined and are shown on Plate IX.

Photo 18. Bank erosion along Maria Ygnacia Creek in February 1962. Sandbags placed as an emergency measure in lower center of photo deflected the current and helped save the house on top of the bank.

Table 12

Maximum Recorded Rainfall Amounts for Various Durations

STATION:	1 HOUR	6 HOUR	24 HOUR	DAILY	CALENDAR MONTH	WATER YEAR
SANTA BARBARA						
Amount:	1.58"	3.84"	7.34"	6.95"	17.30"	45.21"
Date:	2/4/58	1/21/43	1/21-22/43	1/ /14	2/62	40-41
Record:	26 yrs.	26 yrs.	26 yrs.	67 yrs.	97 yrs.	97 yrs.
SAN MARCOS PASS						
Amount:	2.15"*	5.85"	8.80"	8.0±"	28.21"	67.63"
Date:	11/16/65	11/16/65	11/16/65	11/17/65	1/14	40-41
Record:	1 yr.	1 yr.	1 yr.	11 yrs.	51 yrs.	51 yrs.
SAN MARCOS TROUT CLUB						
Amount:	-	-	-	-	25.92"	43.51"
Date:	-	-	-	-	2/62	51-52
Record:	-	-	-	-	20 yrs.	20 yrs.
GOLETA LEMON ASSOCIATION						
Amount:	-	-	-	-	14.79"	46.09"
Date:	-	-	-	-	2/62	40-41
Record:	-	-	-	-	28 yrs.	28 yrs.

Steamflow Records. Stream gaging stations generally consist of a stilling well connected to the stream flow by sensing pipes or ports. The gage itself records water levels in the stilling well on a clock driven chart by means of a pen or, in newer types, by punched holes in binary code on paper tape. The water level is sensed by a float connected to a pulley on the gage. The records obtained from a stream gage are continuous data of water surface level versus time. A rating curve, which shows the rates of flow for various water surface levels, is used to convert stream height data to rate of flow hydrographs.

Accurate stream gage data is not easy to obtain, especially with the large amounts of debris contained in flows in the Goleta Watershed, the rapid rises of stream levels and the high velocities of flow. Debris can and has blocked sensing pipes so that water cannot enter the stilling well. Sensing pipes or ports must be large enough so that the water level in the well can accurately follow rapid changes in stream level. Many records have not been obtained because of inability of the well level to respond to the changes in stream levels.

With high velocities of flow, the entrance to the sensing pipes or ports must be flush with the banks and at right angles to the flow to avoid a venturi or pressure effect which could result in substantial errors in well levels. In December, 1965, the water level in the stream gage well adjacent to the lined

Table 13

Santa Barbara Rainfall
Maximum 6 Hour Amounts
Based on Year Ending in August of the Year Shown

WATER YEAR	6 HOUR AMOUNTS	RANK	6 HOUR AMOUNTS	YEAR
1939-40	1.24	1	3.84	1943
40-41	2.60	2	3.63	1967
41-42	1.56	3	3.07	1945
42-43	3.84	4	2.84	1966
43-44	0.95	5	2.68	1962
1944-45	3.07	6	2.60	1941
45-46	2.09	7	2.25	1952
46-47	1.80	8	2.25	1958
47-48	2.06	9	2.22	1963
48-49	0.96	10	2.09	1946
1949-50	1.52	11	2.06	1948
50-51	0.86	12	1.84	1959
51-52	2.25	13	1.81	1965
52-53	1.43	14	1.80	1961
53-54	1.75	15	1.80	1947
1954-55	1.28	16	1.75	1954
55-56	1.52	17	1.56	1942
56-57	1.52	18	1.52	1956
57-58	2.25	19	1.52	1957
58-59	1.84	20	1.52	1950
1959-60	1.45	21	1.45	1960
60-61	1.80	22	1.43	1953
61-62	2.68	23	1.40	1964
62-63	2.22	24	1.28	1955
63-64	1.40	25	1.24	1940
1964-65	1.81*	26	0.96	1949
65-66	2.84	27	0.95	1944
66-67	3.63	28	0.86	1951

* F.C.D. Gage at 123 E. Anapamu
4-9-65, 10 AM-4 PM

Table 14

Santa Barbara Gage
6 Hour Rainfall Amounts
Comparison of Results Obtained by Different Analyses

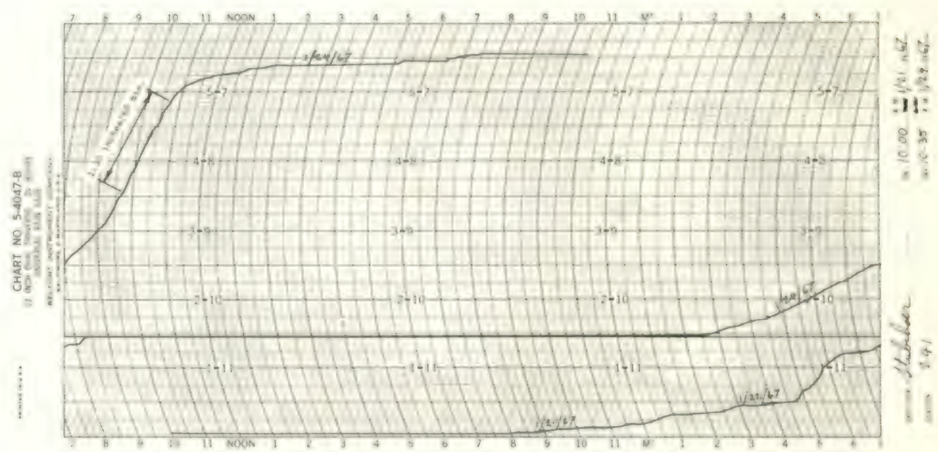
METHOD	2 YR.	5 YR.	10 YR.	25 YR.	50 YR.	100 YR.
Gumbel's	1.76"	2.42"	2.88"	3.44"	3.84"	4.26"
Log-Normal	1.77"	2.45"	2.90"	3.48"	3.90"	4.35"
Foster's	1.69"	2.12"	2.76"	3.34"	3.76"	4.15"

channel of San Jose Creek was observed to be one foot below the water level in the channel due to the fact that the ends of the sensing pipes protruded into the channel and the water had to accelerate locally to get around the pipes. The conversion of pressure head to kinetic energy combined with the curvature of streamlines around the pipe gave the erroneous reading. The average velocity in the channel at the time was 16 feet per second.

Table 15
Seasonal Precipitation as a Function of Elevation
Santa Ynez Mountains

Percent Chance	Coastal Slopes
43%	P = .00487 (E + 3500)
10%	P = .00791 (E + 3500)
4%	P = .00971 (E + 3500)
2%	P = .0110 (E + 3500)
1%	P = .0124 (E + 3500)
	Inland Slopes
43%	P = .00370 (E + 5400)
10%	P = .00601 (E + 5400)
4%	P = .00738 (E + 5400)
2%	P = .00835 (E + 5400)
1%	P = .00942 (E + 5400)

Photo 19. Recording raingage chart for storm of January 21-24, 1967, in El Encanto Heights. This storm caused extensive flooding in the Goleta Valley.



HISTOGRAMS OF MONTHLY RAINFALL AT SANTA BARBARA, CALIFORNIA: 1867-1965

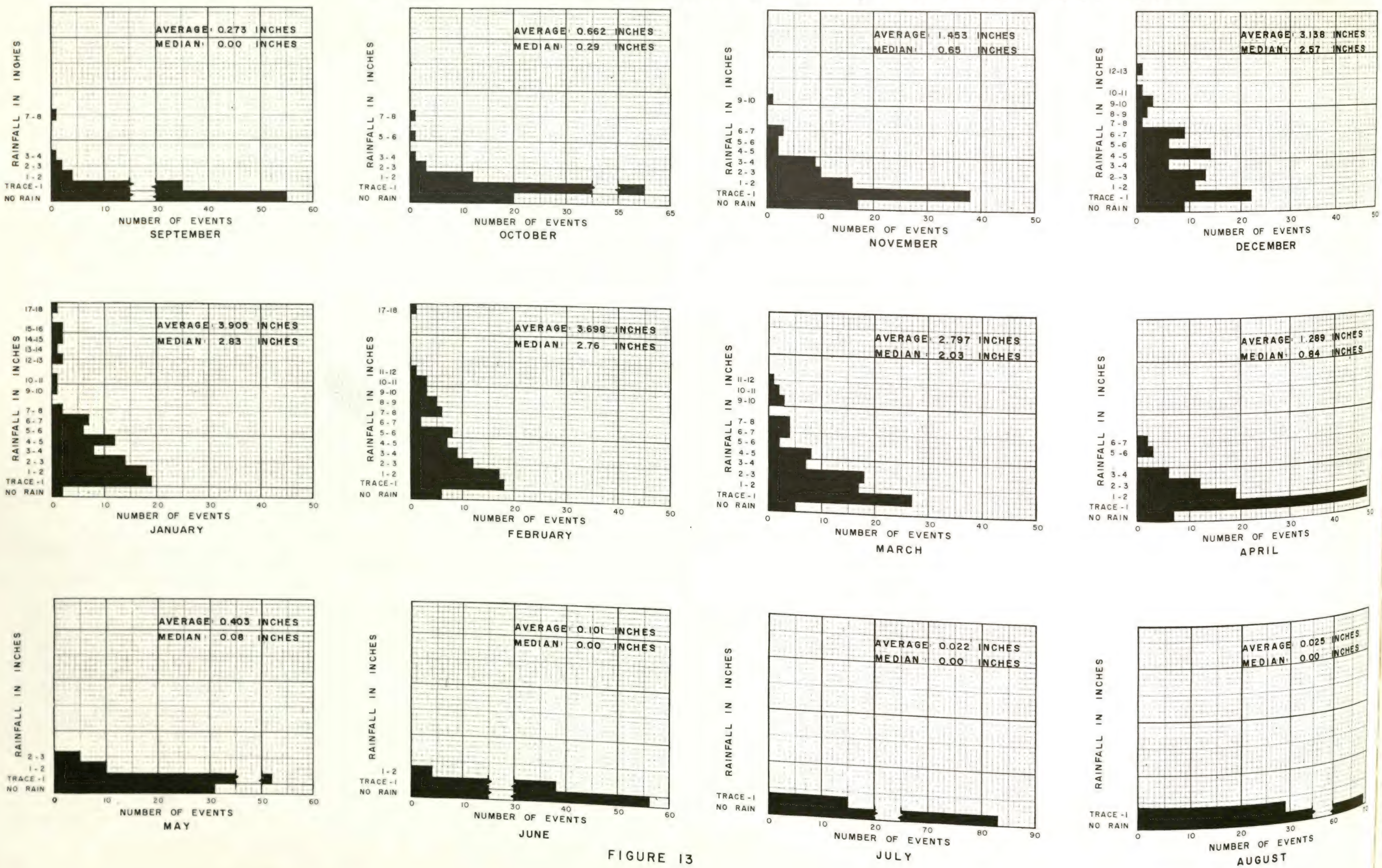


FIGURE 13

The question is often asked if there is a rhythmic cycle of dry and wet periods. Such cycles are not apparent on a year to year basis, as a very wet year may occur in the middle of a seemingly dry period. The 99 years of record of water year rainfall at Santa Barbara were subjected to a time-series analysis by a computer to ascertain if a cyclical variation could be detected and also to determine the trend of water year rainfall. The results are shown in Figure 19. The trend of average water year rainfall for the 99 years of record has been a decrease of 0.00244 inches per year, as indicated in the figure. The time-series analysis detected a cycle of rainfall with a period of 48 years, as shown by the broken line in the figure. It may be seen that year to year variation within the cycle is quite irregular, but some pattern appears to exist. Such an analysis should not be considered reliable for forecasting future rainfall, but as a matter of interest, the predicted water year rainfall for the next 25 years is shown in Figure 19. It should be remembered that the 99 years of record available are but a small sample of the total years of rainfall that have occurred and that conclusions derived therefrom may be erroneous.

Available Stream Gage Records. The United States Geological Survey has been engaged in streamgaging operations for many years. Two USGS gaging stations were established in the Goleta Watershed in 1941, one on Atascadero Creek just below its confluence with Maria Ygnacia Creek, and one on San Jose Creek beneath the old Patterson Avenue bridge.

The Atascadero Creek gage is located in a reach of channel with dikes on both banks. Major flows overtop the dikes upstream and flood around the gage location and hence are not recorded. The records from the Atascadero Creek gage probably indicate a maximum stage in the channel just as the dikes are being overtopped and then the stage drops, though the flow increases, as the dikes erode away and an increasing portion of the flow bypasses the gage. Thus the true hydrograph of the total flow is not recorded and the records from this gage cannot be used for hydrograph analysis. Estimates of the peak flow at and around the gage have been made from high water marks for various floods, but this is not a precise procedure and the amounts computed by different agencies vary widely. Published figures for peak floods at the Atascadero Creek gage are sometimes believed to be quite low.

The San Jose Creek gage is located in an entrenched channel where there is little likelihood of flow bypassing the gage. There is some indication that the sensing ports have been plugged at various times, but the records are generally fair. The watershed above the gage is shaped like an inverted "L", unlike other watersheds in the area. For this reason time of concentration and hydrograph shape are not typical for the Goleta Valley. Prior to 1965, there was no recording rain gage in or near the watershed, so correlation of runoff with rainfall was not possible.

In the early stages of this AB 1144 Watershed Survey the importance of obtaining additional stream gage and recording rain gage information was recognized. The U.S. Weather Bureau generously supplied several recording rain gages which were placed at strategic locations in the watershed. Fischer and Porter punched tape stream gages were purchased by the Santa Barbara County Flood Control District and installed in Glenn Annie Creek just above Highway 101, San Pedro Creek a short dis-

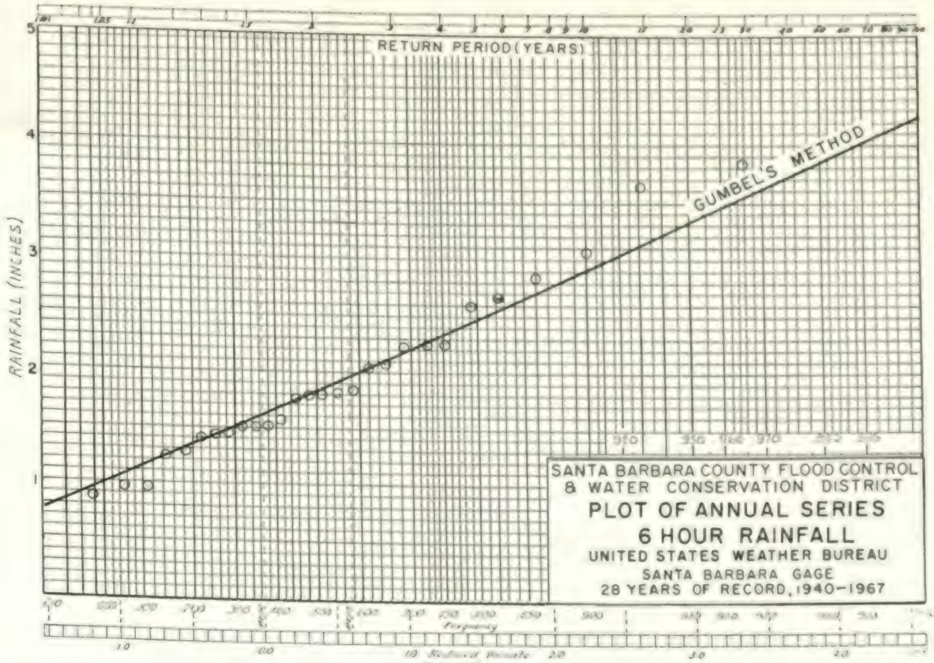


FIGURE 14

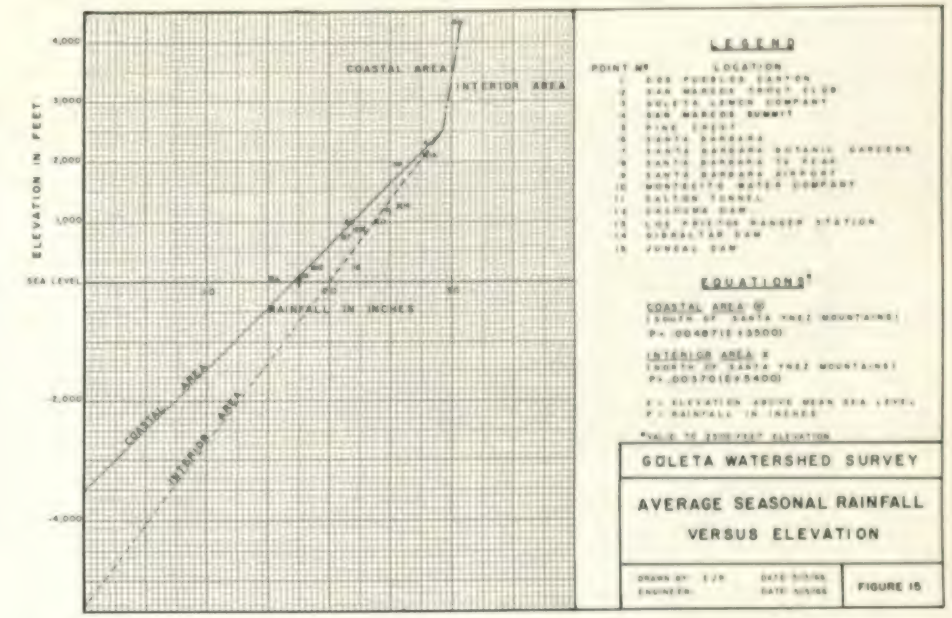
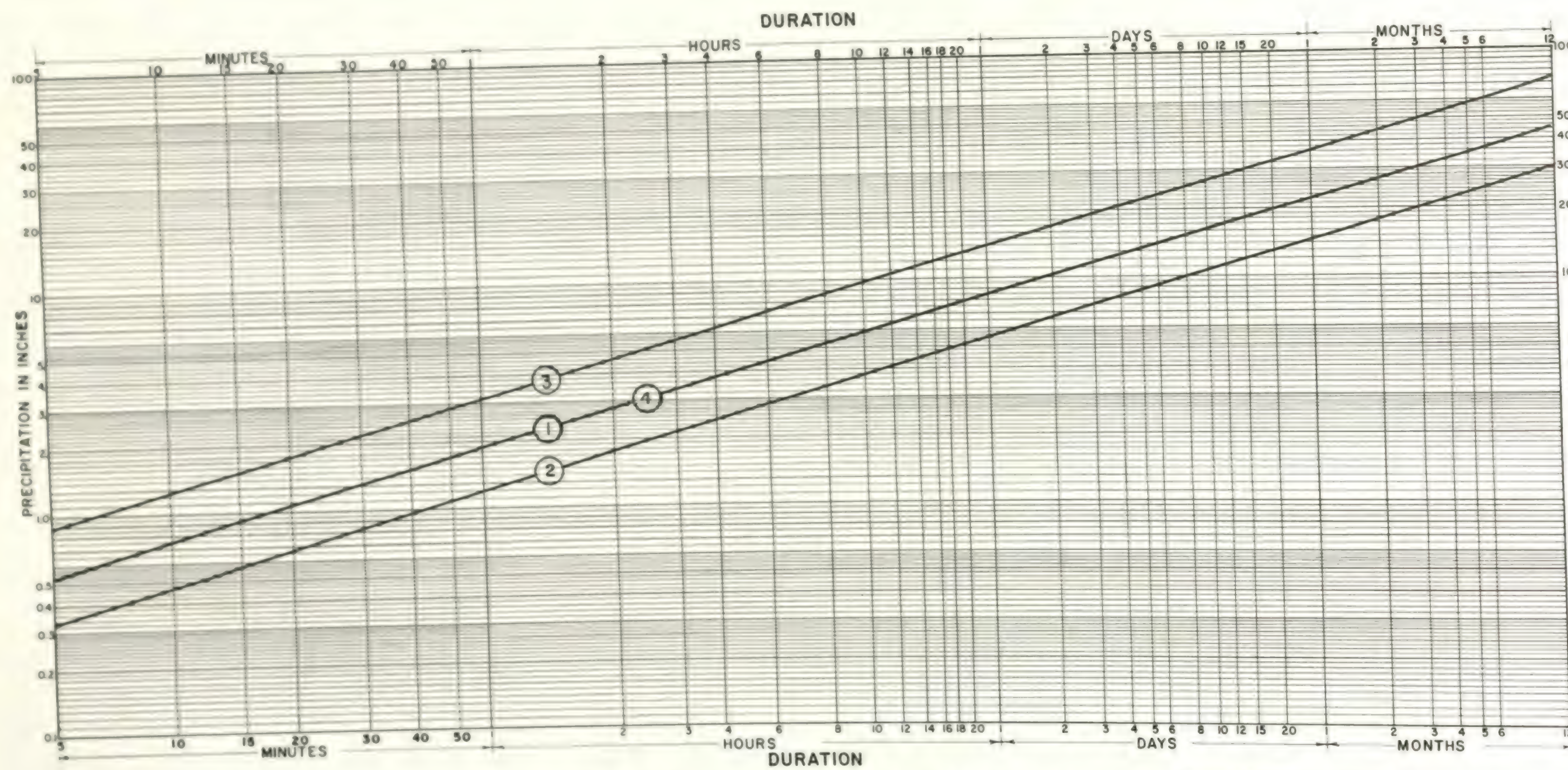


Photo 20. Debris deposits in El Capitan Canyon following a storm on the watershed burned by the Refugio Fire of 1955. Note the typical pattern of logs backed up by rocks and silt.



CURVE Nº	STATION	STORM FREQUENCY	%
1	SANTA BARBARA	100 YEAR	1
2	SANTA BARBARA	10 YEAR	10
3	SAN MARCOS SUMMIT	100 YEAR	1
4	SAN MARCOS SUMMIT	10 YEAR	10

SANTA BARBARA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

GOLETA WATERSHED SURVEY

PRECIPITATION DEPTH — DURATION FREQUENCY CURVES

APPROVED J. Mettikhan

DATE JUNE 1968

FIGURE 16

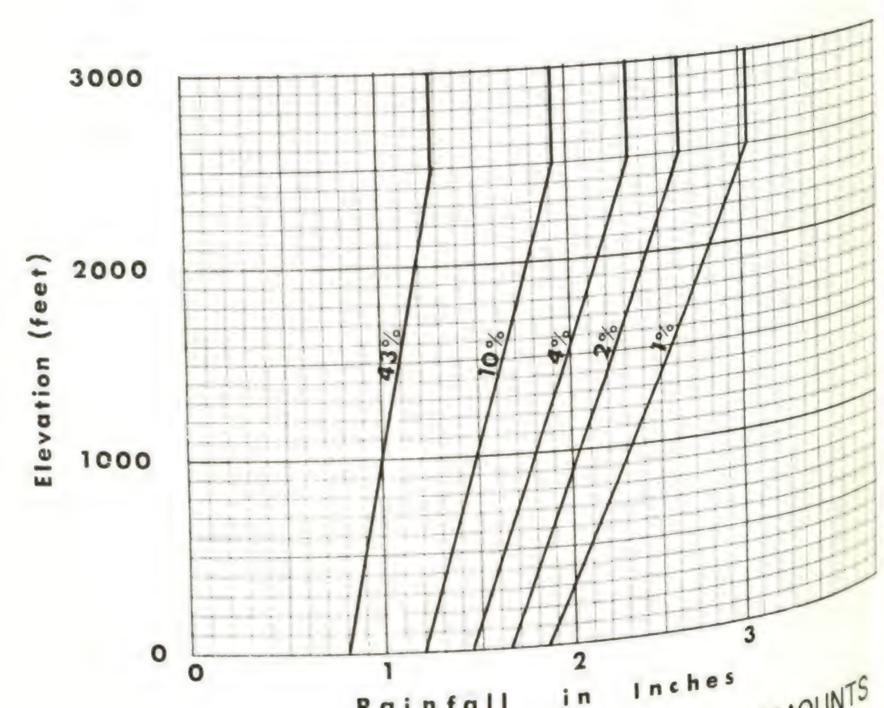
tance above Highway 101, San Jose Creek in the new lined section below Hollister Avenue, and Atascadero Creek at Puente Drive. An earlier installation at Hospital Creek below Hollister Avenue had to be abandoned because of silting problems.

Records from the Flood Control District gages were of variable quality in 1963 and 1964, when the deficiencies of the original installations were being corrected. The data from most stations is now good, but the period of record is too short to permit statistical analysis. It has been possible, however, to correlate recording rain gage data with stream flow data for several major storms. The results of this correlation have revealed much about the runoff characteristics of Goleta Watershed which was not previously known.

Analysis of Stream Flow Records. Recorded hydrographs may be analyzed in several ways. The area under the hydrograph for a given period is the total volume of flow for that period. The total volume may be accumulated for all the years of record and plotted as a mass, or summation, curve. The mass curve is used for the design of reservoirs and the determination of safe yield of surface water supplies. The maximum rate of flow, called peak flow, may be determined. The total volume of flow for a given storm may be compared with the storm rainfall volume, if known, to estimate the amount of rain which is absorbed by the ground, stored in depressions, held by vegetation, evaporated, and otherwise prevented from running off on the surface.

Peak Flows. The peak flows from various storms may be analyzed to determine the probability of their occurrence and the prediction of flood flows for use in the design of flood control works. Usually the annual series method of frequency analysis is used, in which the peak flow in each water year for which records are available is determined and ranked in order of magnitude. A plotting position is determined for each value by a suitable formula, the values are plotted on probability paper, and a line of best fit is drawn through the plotted points. The result is a graph with peak flow as ordinate and frequency, or return period, as abcissa, from which the peak flow for any frequency can be read. Because hydrologic data usually does not have a normal probability distribution, special types of probability paper are needed. For this study, the paper based on the work of Prof. Gumbel was used, as discussed under "Analysis of Rainfall".

There are limitations on the use of frequency analysis to determine design flows. The period of stream gage records must be quite long to establish a definite trend. A minimum of 20 to 25 years of record is needed in the study area. The plotted points should tend towards a straight line to permit a mathematical curve fitting procedure to be used for reliable extrapolation to the 1% or 0.5% flood. For Santa Barbara County and other semi-arid regions, the plotted points indicate two distinct straight lines in a "dog leg" pattern, with the break at the 2 or 3 year return period. This break makes it impossible to reliably extrapolate the records to determine, for instance, the 1% flood from 25 years of records. This "dog leg" problem was discussed with Prof. Gumbel, who said that his theoretical statistical methods do not apply where the break is very pronounced as it is in Santa Barbara County.



GOLETA WATERSHED 60 MINUTE AMOUNTS

FIGURE 17

Photo 21. Stream gage installation on San Pedro Creek. The punched tape unit records the stream levels in the stilling well, which is connected to the concrete lined channel by pipes.

Figure 20 shows plotted points for peak flows from the Atascadero Creek streamgage records. A straight line fitted by the Gumbel method is shown. Note the great deviation from the plotted points, which suggests that the records do not fit the Gumbel frequency distribution. Another line, fitted by a parabolic regression procedure, is also shown. This line is closer to the plotted points, but is not related to any accepted frequency distribution and therefore constitutes a "forced fit" which is not necessarily better than the straight line. A third line is based on Gumbel's procedure using the logarithms of the data and it appears to deviate on the high side of the maximum observed floods. This figure is primarily for purposes of illustration and should not be used for design. The measured high peak flows are not very accurate and the records do not reflect the urbanization of large portions of the watershed, in addition to the curve fitting problems. Combining runoff records which are sometimes questionable with analyses which are not mathematically exact yields results which are, at best, only "ballpark" estimates of peak flow, yet the building of dams, weirs, channels, storm drains, bridges and other structures cannot wait until the true values are known, so the engineer is compelled to combine the best records and methods available with judgement gained from experience to determine design flows.

Another method of peak flow analysis often used is to determine the "runoff coefficient" for use in the so-called rational formula

$$Q = C\ i\ A$$

where "Q" is the peak flow in cubic feet per second, "i" is the rainfall intensity for a duration equal to the time of concentration, and "A" is the watershed area in acres. If "Q" is known from streamgage records, "i" is known from recording raingage records, and "A" is known from topographic maps, the runoff coefficient is

$$C = \frac{Q}{i\ A}$$

"C" may be determined for a flood of record and applied to a rainfall of the design frequency.

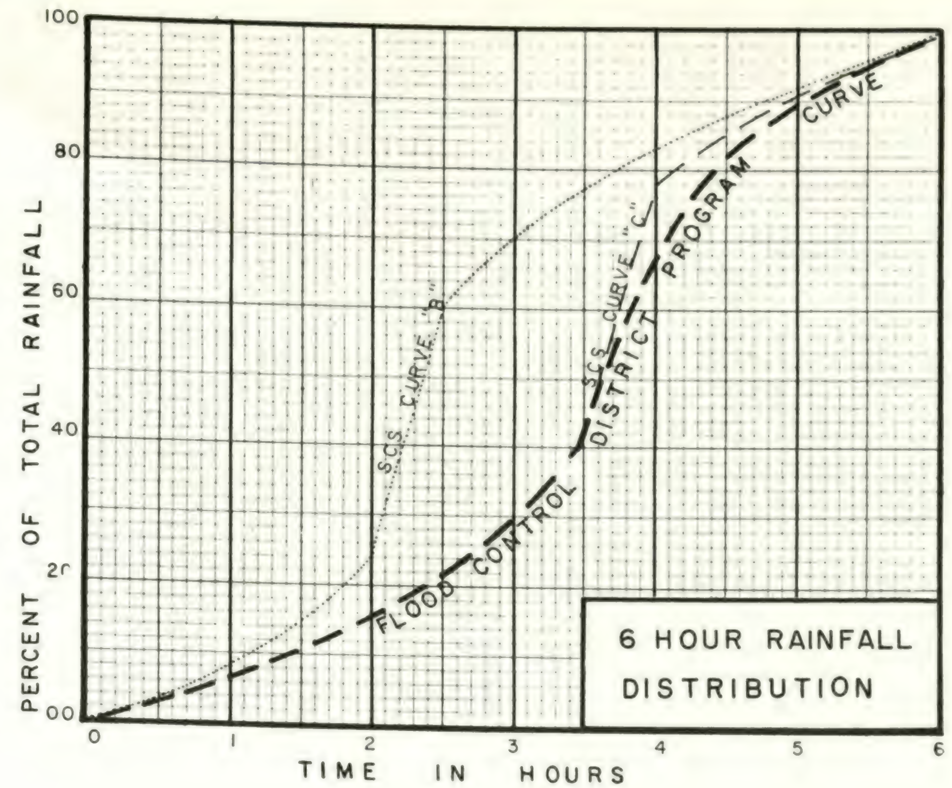


FIGURE 18

The deficiency of this method is that "C" is not constant for a given watershed and rainfall intensity, and precipitation is not often uniform over the watershed, as assumed. However, since the method is simple it is widely used in engineering practice, and in most cases the runoff coefficient is not derived from observed records, but rather is obtained from reference books and may be greatly in error, especially for larger undeveloped areas. There are many variations of the rational method, and some of the better approaches vary "C" with the rainfall intensity.

<u>Unitgraphs</u>. Where the entire hydrograph, not just the peak flow, is needed, procedures are much more complex. It is necessary to determine the base width or time, the time to peak, the time of recession, the peak flow, and the total volume of flow for the hydrograph to roughly define its shape. The problem is complicated by the fact that the shape of a hydrograph on small watersheds such as those in the Goleta Valley is closely related to the rainfall pattern, which varies greatly from storm to storm. In order to isolate the effects of rainfall distribution, the theory of the unit hydrograph, or unitgraph, was developed in the early 1930's. A detailed discussion of this method is beyond the scope of this chapter, but since it is the accepted method of analyzing hydrographs, the principles must be mentioned.

The unitgraph is the hydrograph which would result from a unit storm lasting a unit period on the watershed being studied; for instance, a storm with a duration of one hour resulting in one inch of runoff. The unit duration used depends on the characteristics of the watershed and generally is 1/5 the time of concentration. The time of concentration is the time required for water to flow from the most remote point in time in the watershed to the design point.

A study of hundreds of hydrographs indicated two facts which are basic propositions of the unitgraph method:

I. <u>Linearity</u>. The base width of unitgraphs for given watersheds is constant and independent of rainfall. Therefore, peak flow varies directly with rainfall excess, which is the amount of rainfall which runs off on the surface. For instance, if an excess rainfall of 2 inches in one hour occurs the resulting hydrograph may be obtained by multiplying by two the ordinates of the unitgraph for 1 inch in one hour.

II. <u>Superposition</u>. Hydrographs may be added directly without distorting the resulting composite hydrograph. This principle enables hydrographs to be constructed for complex storms of several unit periods. Hydrographs for each unit period are developed from the unitgraph and rainfall data and are recorded in the proper time sequence. The several hydrographs are then added to obtain the total hydrograph.

Using these principles and having rainfall and runoff data for fairly large storms from recording gages, it is possible to derive unitgraphs for given watersheds. The unitgraph is the best known indication of the characteristics of a watershed, as it integrates the effects of all the variables which determine the shape of the runoff hydrograph.

Prior to 1964, there were no recording raingages in the watersheds above the Goleta Valley. Thus it was not possible to derive unitgraphs from observed hydrographs, and methods based on estimates of rainfall, infiltration rates, times of concentration, and other variables had to be used. In November and December, 1965, and January, 1967, large flows and floods occurred for which both the required rainfall and runoff data were obtained and unitgraphs were derived. Storm rainfalls by 15 minute increments and runoff hydrographs were plotted on the same graphs. The total volumes of surface runoff, called rainfall excess, were obtained by measuring the areas under the hydrographs and were converted to depths in inches over the watersheds. These were subtracted from the rainfall depths to determine the amounts of rain which were intercepted by vegetation, infiltrated into the soil, held in surface storage, evaporated, or otherwise "lost"* to surface runoff.

Lines separating apparent rainfall excess amounts from the losses were drawn on the rainfall histogram to determine the loss rates. (The loss rates are very important because they directly influence the size of floods, but they are very difficult to estimate in the absence of adequate data.) The impervious portions of watersheds (streets, roofs, etc.) hydraulically connected** to the channel system were not considered as subject to the loss rates and were treated separately.

**In surface water hydrology, rainfall which does not run off on the surface is considered a loss. This should not be construed to mean it is lost to beneficial uses, such as ground water recharge, plant evapo-transpiration, etc.*

***Impervious areas from which runoff must flow across substantial pervious areas before reaching curbed streets, storm drains, or channels, are not considered as hydraulically connected.*

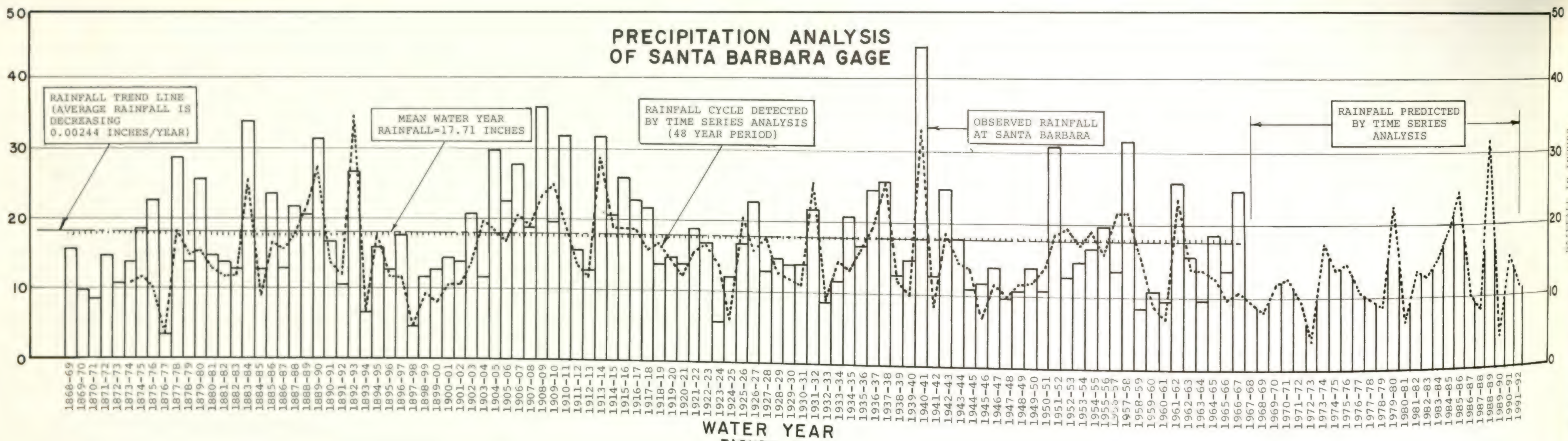


FIGURE 19

For first trials, unitgraphs were estimated and applied to each increment of rainfall excess in turn. The resulting hydrographs were summed to obtain composite hydrographs which were compared with the observed hydrographs. If agreement was not good, the assumed unitgraphs were adjusted and the process repeated until satisfactory results were obtained. Figures 21 and 22, show recorded and observed hydrographs together with rainfall excess and losses. Figure 23 shows the derived unitgraphs for San Jose, Atascadero and Mission Creeks.

5. HYDROGRAPH CALCULATION

The object of the analyses discussed to this point has been to obtain data for the establishment of a procedure to calculate hydrographs of given frequencies for all streams in the Goleta Watershed by the unitgraph method. Viewing each watershed as a system with rainfall as the input, it is desired to determine how the system operates on the input to determine the output, which is the resulting hydrograph. Because of the facts previously mentioned, the 6-hour storm with the distribution shown on Figure 18 was selected as the design storm.

Before the unitgraph procedure can be applied to the rainfall, it is necessary to determine the amount of rainfall which runs off by deducting the loss rate from the rainfall increments for the pervious fraction of each watershed, and then adding this to the incremental precipitation on the impervious, hydraulically connected fractions of the watershed. The result is called the "net rainfall", and is the area enclosed by the hydrograph. The impervious fraction of each watershed was determined from aerial photos and topographic maps. The loss rate was derived from observed hydrographs and adjusted for the antecedent moisture conditions, or the saturation of the ground before the design storm.

In order to apply the derived unitgraphs to all watersheds in the study area, it was necessary to reduce the unitgraphs to some common denominator which reflected the physical characteristics of each watershed. The concept of watershed lag time was used to accomplish this reduction. Lag time is defined, for this study, as the time from beginning of runoff to the time

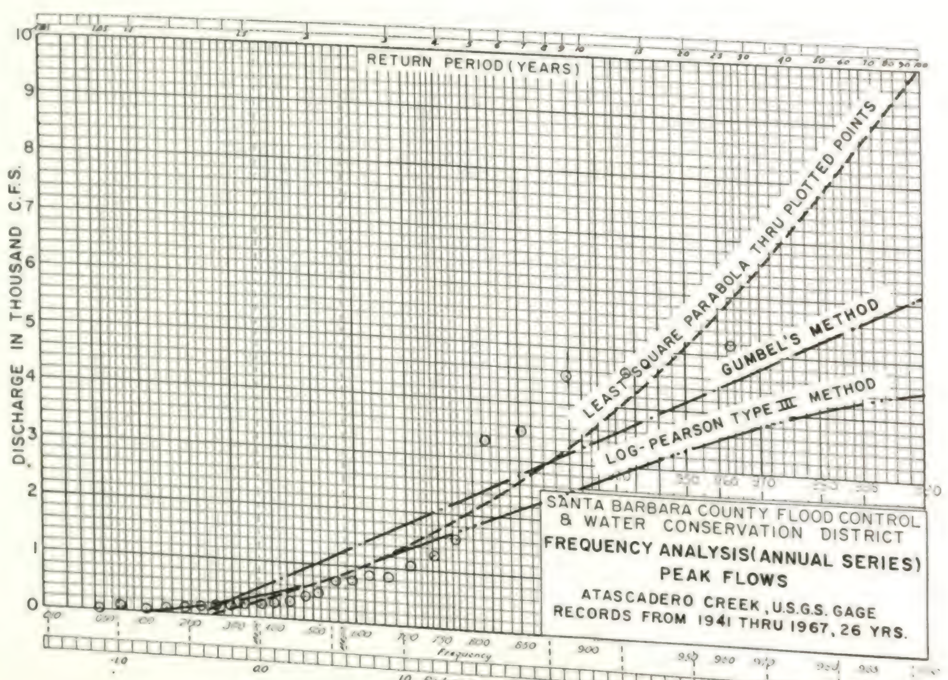


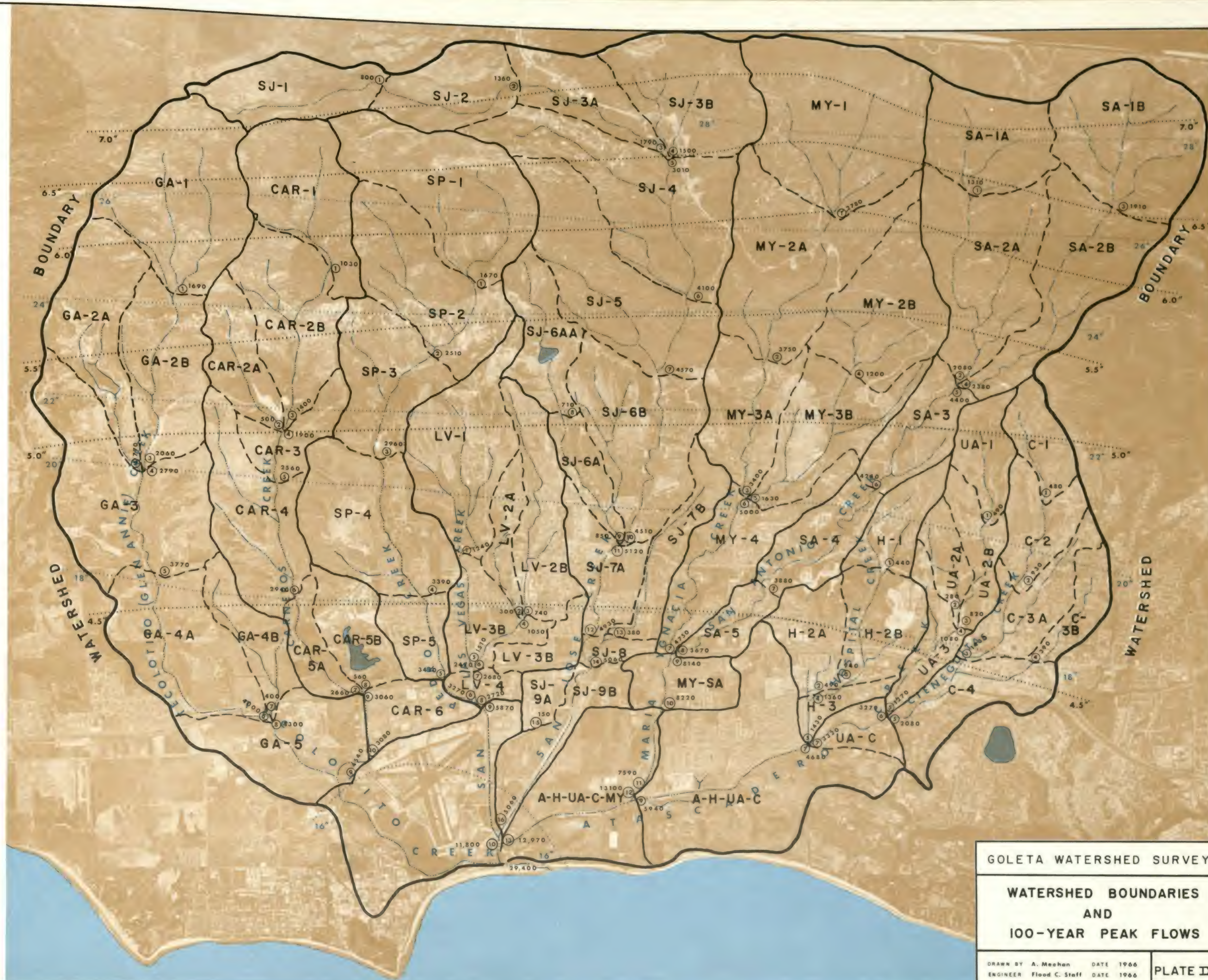
FIGURE 20

when 50 percent of the runoff volume has flowed by the design point. Lag time is taken as a function of three physical constants of the watershed, the length of the longest watercourse, the length along the watercourse from the design point to a point opposite the center of gravity of the watershed area, and the average slope of the longest watercourse; and of one variable factor, the average Manning's hydraulic roughness factor.

The derived unitgraphs were converted to a dimensionless basis with watershed lag time as the abcissa and percentage of runoff as the ordinate. Two average unitgraphs (Figure 24) were drawn from the unitgraphs previously derived, one for mountainous areas and one for valley-foothill areas. All Goleta streams were placed in one of these classifications, the watersheds defined, areas measured, lag times calculated, six hour rainfall amounts, percentages impervious, and loss rates determined, and the data processed through an electronic digital computer to calculate the design hydrographs using the principles previously discussed. (This work would have been prohibitively costly to do manually with desk calculators.)

Hydrographs of 1% frequency for Atascadero and San Jose Creeks are shown in Figure 25. All hydrographs are on file in the Flood Control District office and may be examined by interested parties. The peak flows from this program for the 1% frequency are shown on the watershed map, Plate X.

The results obtained from this program are believed to be as good estimates of what flows may occur as may be made with existing engineering techniques. Effects of loss of watershed cover by fire, the forming and breaking of natural dams, and the debris entrained in the flow have not been included and the results published herein must not be used blindly in designing bridges, channels and dams. Engineering judgement must be used in providing driftways and applying bulking factors.



L E G E N D

———	MAJOR WATERSHED BOUNDARIES
— — —	SUBWATERSHED BOUNDARIES
①	FLOW POINTS
XX-1	SUBWATERSHED CODE

SCALE 0 2000 4000 (FEET)

CREEKS:

GA	GLEN ANNIE
CAR	CARNEROS
SP	SAN PEDRO
LV	LAS VEGAS
SJ	SAN JOSE
MY	MARIA YGNACIA
SA	SAN ANTONIO
H	HOSPITAL
UA	UPPER ATASCADERO
C	CIENEGUITAS
A	ATASCADERO
1280	PEAK DISCHARGE IN CUBIC FEET PER SECOND AT FLOW POINTS

100 YEAR 6 HOUR ISOHYETS (INCHES)

AVERAGE WATER YEAR ISOHYETS (INCHES)

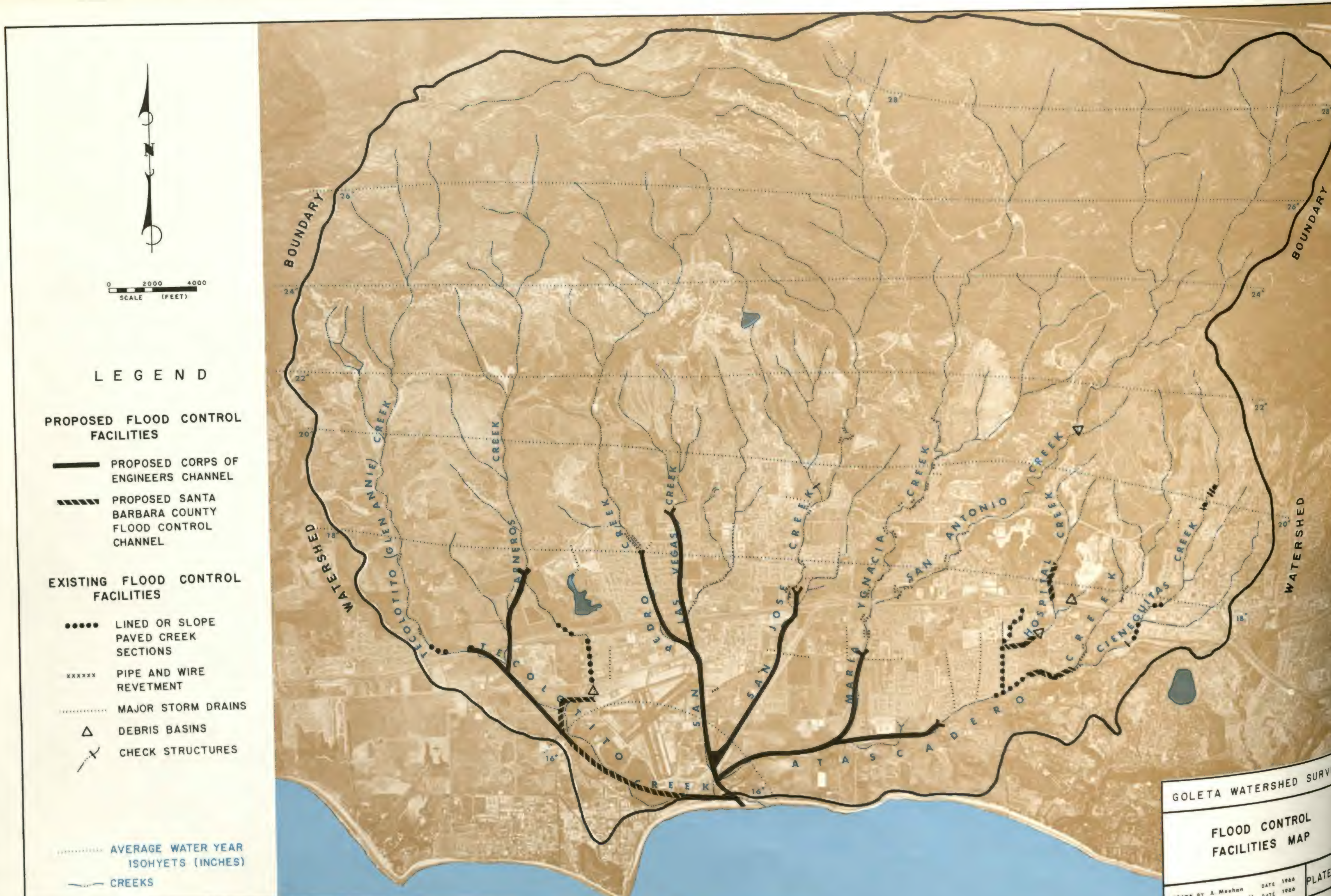
CREEKS

GOLETA WATERSHED SURVEY

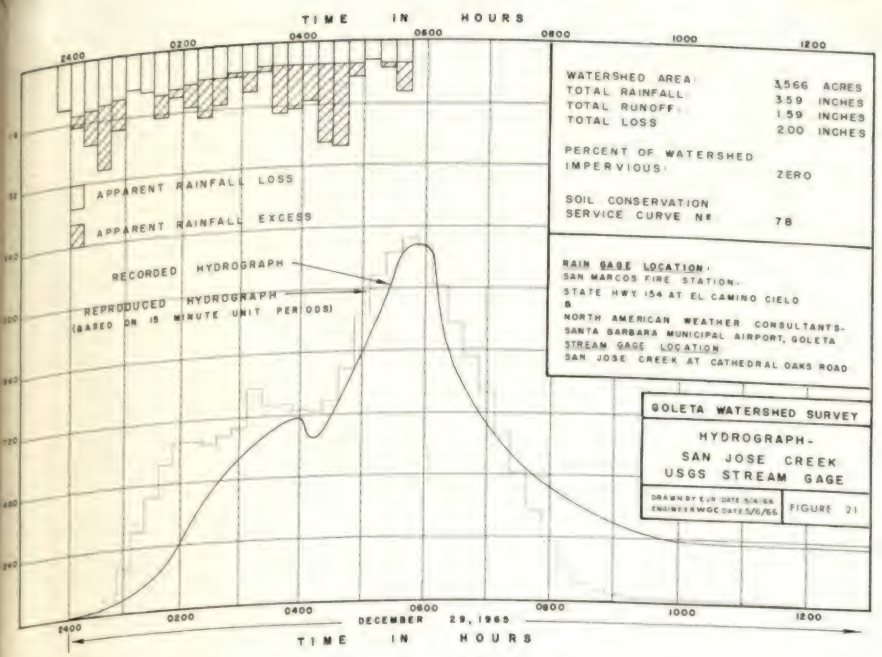
WATERSHED BOUNDARIES AND 100-YEAR PEAK FLOWS

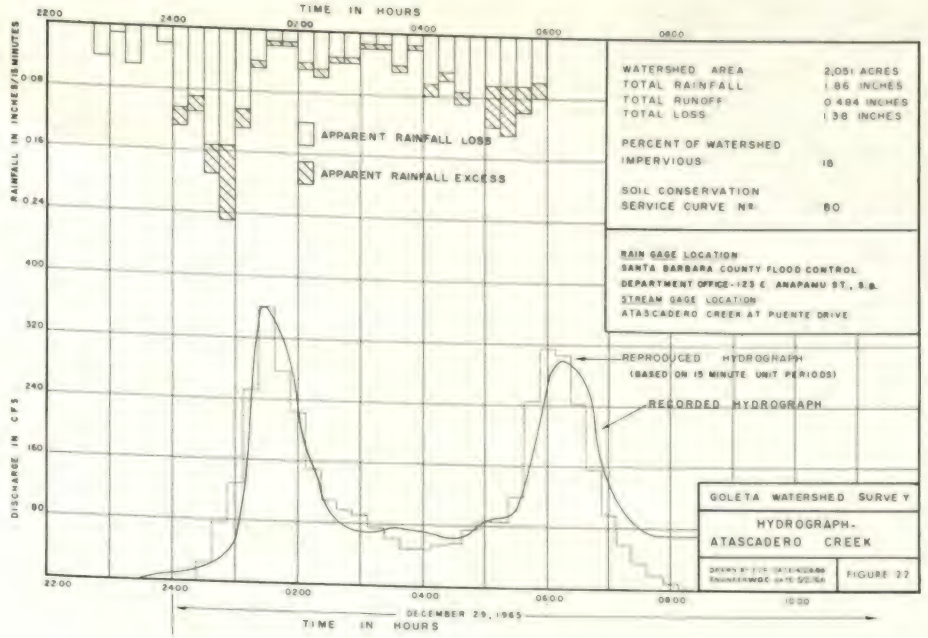
DRAWN BY A. Meehan DATE 1966
ENGINEER Flood C. Staff DATE 1966

PLATE IX



0 2000 4000
SCALE (FEET)
LEGEND
PROPOSED FLOOD CONTROL FACILITIES
PROPOSED CORPS OF ENGINEERS CHANNEL
PROPOSED SANTA BARBARA COUNTY FLOOD CONTROL CHANNEL
EXISTING FLOOD CONTROL FACILITIES
LINED OR SLOPE PAVED CREEK SECTIONS
PIPE AND WIRE REVETMENT
MAJOR STORM DRAINS
DEBRIS BASINS
CHECK STRUCTURES
AVERAGE WATER YEAR ISOHYETS (INCHES)
CREEKS
WATERSHED BOUNDARY
TECOLOTITO (GLEN ANNIE) CREEK
CARNEROS CREEK
TECOLOTITO CREEK
SAN PEDRO CREEK
LAS VEGAS CREEK
SAN JOSE CREEK
MARIA YGNACIA CREEK
SAN ANTONIO CREEK
HOSPITAL CREEK
ATASCADERO CREEK
CIENEGUITAS CREEK
16"
18"
20"
22"
24"
26"
28"
GOLETA WATERSHED SURVEY
FLOOD CONTROL FACILITIES MAP
DRAWN BY A. Meehan DATE 1966
ENGINEER Flood C. Staff DATE 1966
PLATE X





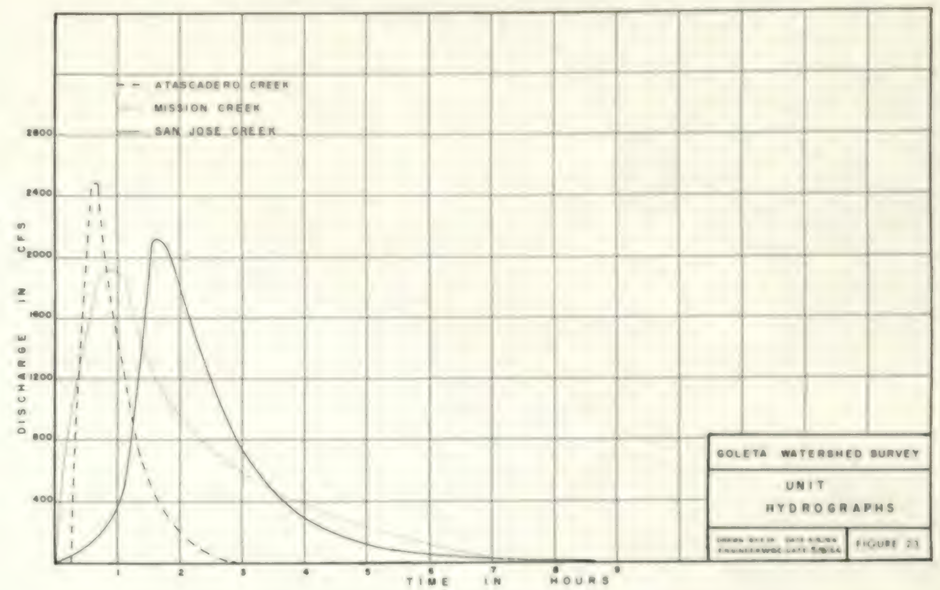


Photo 22. *San Pedro Creek and Stow Canyon Road. Bridge destroyed, banks eroded, and trees downed by flood of January 24, 1967.*

6. <u>FLOOD HAZARDS</u>

Flood hazards are usually thought of as inundation by water. This is bad enough for most people, as the water is seldom clean, and when the floods recede, a sticky residue of silt is left on everything beneath the highwater mark. In addition to inundation, however, the Goleta Valley is subject to other types of flood hazard, including bank erosion by stream actions, and high velocity debris flows or flash floods, especially from burned watersheds.

<u>Bank erosion</u> is not easily predictable, as it is subject to the vagaries of stream meanders. It is possible for such erosion to undermine structures, such as buildings and bridges, and thereby cause their complete failure. Four bridges were lost because of erosion in the floods of January 24, 1967. Areas of known or anticipated bank erosion hazard are delinated on Plate XI.

<u>Flash floods</u> are high velocity debris flows, usually resulting from an intense, though possibly brief, rain on a burned watershed. On November 9, 1964, six weeks after the Coyote Fire, a storm with a total rainfall of from 0.83 inches at the Goleta Airport to 1.40 inches at San Marcos Pass caused record high flows in San Antonio Creek. Eyewitnesses reported that a wave 20 to 25 feet high roared down the dry creek bed at a velocity of about 22 feet per second, causing the ground to tremble as in an earthquake. The wave contained boulders, trees, black ash-mud, and water, being quite viscous and dense, the flow resisted turning more than water and forced itself over banks at curves where overflow would not normally occur. The ranger at Tucker's Grove Park reported that the flood sounded like a freight train speeding down Cathedral Oaks Road and that trees along the channel were swaying like wheat in a wind. Very large debris was transported by this flood.

In the Goleta Watershed, flash floods are believed to be caused by the breaking in chain reaction fashion of numerous small natural dams caused by slides and log jams in the mountainous portions of the watersheds. Such flows cannot be accurately predicted, but must be accounted for by bridge designers by use of a generous driftway. The streams which may be expected to experience flash floods include Glenn Annie, Carneros, San Pedro, San Jose, Maria Ygnacia, and San Antonio Creeks.

<u>Flooding</u> is the inundation of land and improvements by water which has overflowed from streams. If the overflow has sufficient velocity, it may dislodge buildings, trees, and vehicles, and sweep people and animals away. If the design flow is known, it is a relatively easy matter for the engineer to determine areas subject to this type of flooding.

Photo 23. *Light duty pipe and wire revetment in San Antonio Creek destroyed by flash flood from Coyote Fire burned area on November 9, 1964.*

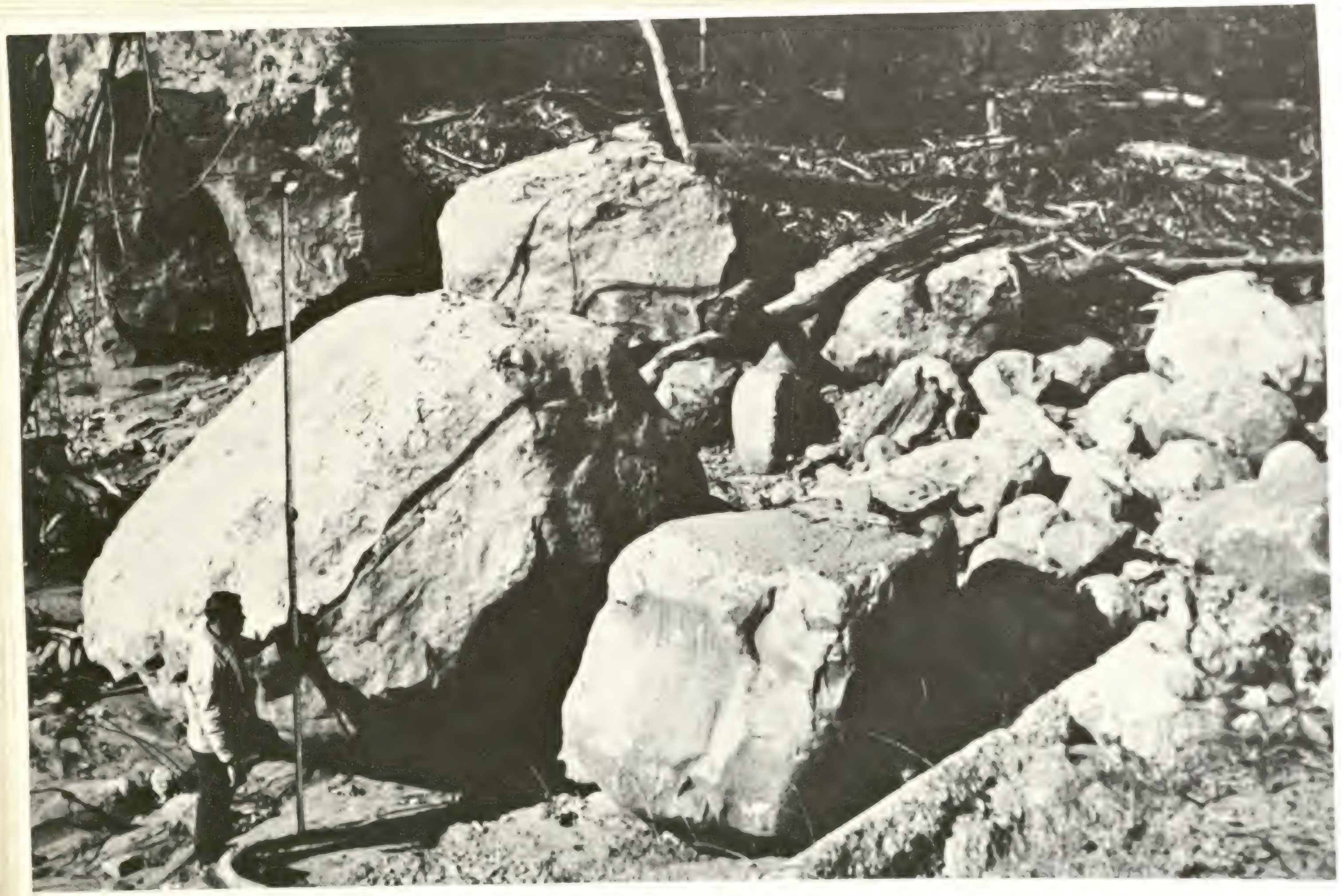


Photo 24. Debris transported by flash flood of November 8,1964, in San Antonio Creek. The rocks in the foreground were moved about 1/4 mile and weigh up to 420 tons. The logs and tree trunks left in the background by the flood cover about 1/2 acre.

Photo 25. Debris deposits in concrete lined channel of Montecito Creek following flood of November 8,1964. The concrete invert was completely eroded away upstream of this photo.

Early in this AB1144 study, university students were employed to survey all the streams in the Goleta Valley to determine their slopes, cross-sections, and alignments. The hydraulic capacity versus depth at each section was calculated and compared with the 1% hydrograph for the given reach of stream. If the expected flow exceeded the capacity, flooding was assumed to occur. Historical records of flooding were checked, if possible, to verify the results. Plate XI shows the areas subject to overflow in a 1% flood.

After this study was initiated, the U.S. Army Corps of Engineers was authorized by Congress to study the Goleta Valley streams, among others, for flood control and allied purposes. Copies of the stream surveys completed under this AB1144 project were transmitted to the Corps of Engineers, and it is understood the surveys were of great value.

Flooding is often incidental to two other factors. The first is sediment, which frequently deposits in flatter reaches of streams, occupying cross-sectional area needed for the conveyance of water. If the sediment is not promptly removed, flooding may result.

The other related factor is drift, or floating debris. Trees and logs are most troublesome in the larger streams, where bridges may be completely plugged, causing flow to flood around the obstruction. In the smaller watercourses, almost anything from lemon tree clippings to mattresses has been known to clog drains and channels.

Sheet flow is the flow of water not yet collected in streams, lakes, or other established waterways. Legally, there is a great distinction between flood waters and sheet flow, though both can cause inundation, and the affected property owner probably doesn't care which type of flow flooded his land. Most drainage problems with the relatively new housing tracts in the Goleta Valley result from sheet flow. The major watercourses are usually well provided for, but the regrading of a back yard can change the flow of sheet water enough to cause many problems. Also, as sheet flow is often collected in smaller culverts and storm drains, inlet clogging is a common problem. Clogged inlets at sag points in streets may and have caused water to pond up deep enough to flood adjacent houses.

Erosion, other than stream bank erosion, is of concern to the flood control engineer because it generates sediment which often deposits in creeks and channels. Erosion also causes much loss in itself. In new subdivisions, with raw slopes and unplanted parkways, damage is often severe, yet could be avoided by the application of elementary principles of soil conservation.

Photo 26. Severe hillside erosion on bare, un-terraced hillside. The sediment from this erosion damaged the orchards below and filled up the stream channels. Photo by Santa Barbara News-Press.

Photo 27. Failure of a gunite lined channel on Cieneguitas Creek in January,1967, due to inadequate subdrainage and side drainage.

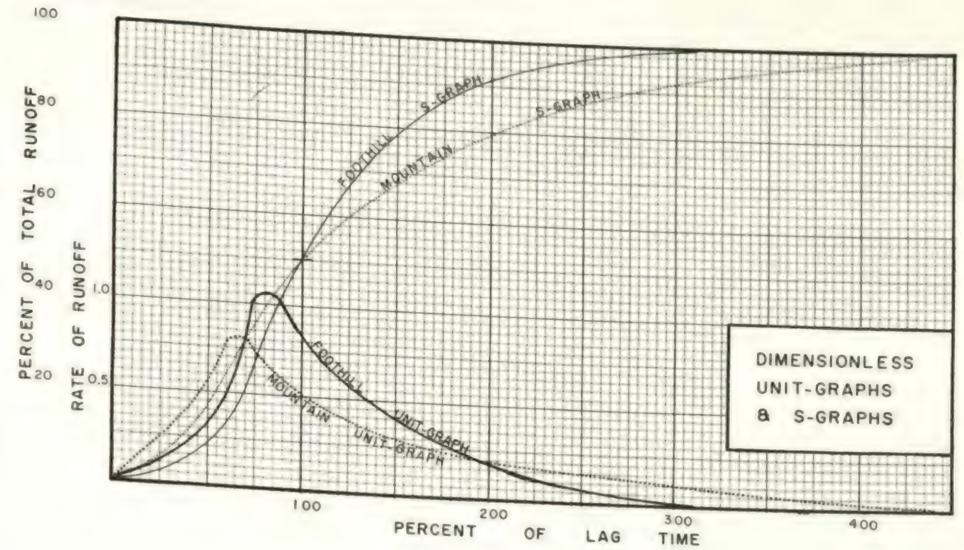


FIGURE 24

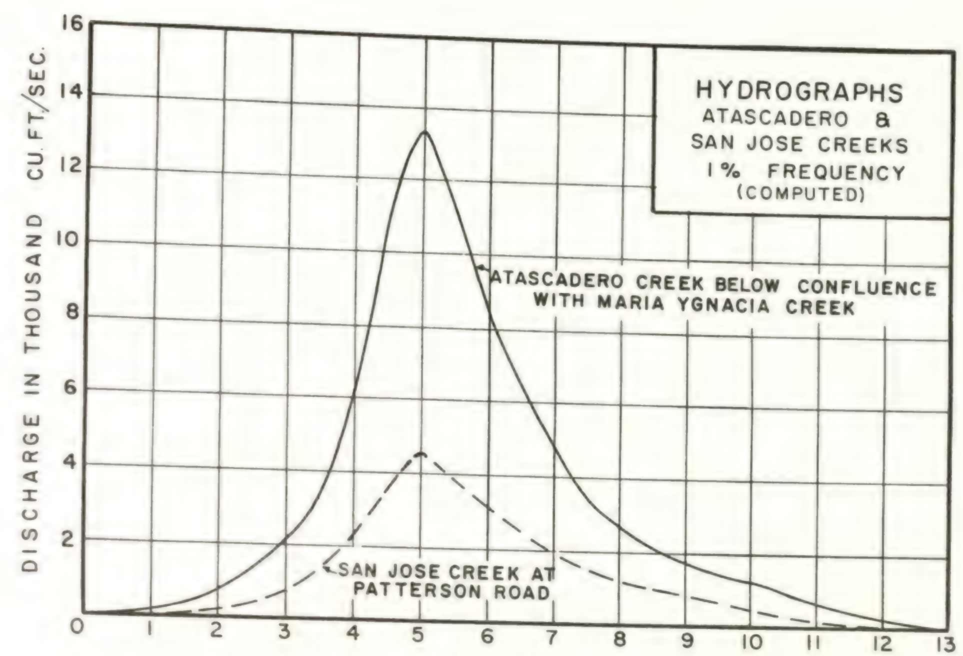


FIGURE 25

Photo 28. Overflow from Maria Ygnacia Creek flooding across South Patterson Avenue. January 24,1967. Photo by U.S. Geological Survey.

Photo 29. View from Ward Memorial Freeway showing overflow from Atascadero Creek. Note high water mark on fence. Photo by California Division of Highways.

B. FLOOD CONTROL

1. INTRODUCTION

The term "flood control" is commonly used in the United States to describe activities intended to reduce damages or secure relief from hazards due to floods. In a way, this term is not truly descriptive; floods are never really controlled, as it is possible to experience a flood more severe than the design flood. The Australians use the term "flood mitigation", but in this chapter the conventional American usage will be followed.

Relief from flood may be generally secured in three ways:

1. Installation of protective works
2. Reduction of the flood stage without greatly changing the peak discharge
3. Reduction of flood flows by regulatory storage, change in land use, or similar methods.

The principles of flood control are simple. Short of being able to control the weather, hydraulic engineers design channels which are adequate to convey the design flow and/or construct dams which can retain the flood waters and release them at a safe rate. In practice, the application of these principles becomes very complex, and requires the talents of economists, soil conservationists, foresters, politicians, lawyers, social scientists, construction men, and numerous other disciplines in addition to engineers. A complete flood control program consists of more than just dams and channels. It should be a comprehensive system of works integrated to yield the greatest economic return on the money invested, and in addition to protecting against direct overflow of streams, it should include a program of managing watershed resources to prevent erosion and sedimentation and debris flows; conserve valuable, irreplaceable topsoil; guard against disastrous forest fires and discourage expensive urban development in areas of high flood hazard. Values such as recreation, fisheries and wildlife, water conservation, power generation, navigation and pollution control should be considered.

In this section flood control measures are briefly described and their applications in the Goleta Watershed are discussed.

2. ENGINEERING MEASURES

Channel Improvement: Adequate channel capacity for flood flows may be provided in different ways. The most obvious method is to simply dig the channel deeper and wider, and indeed this is done in many smaller channels in relatively flat terrain. In dealing with larger streams, however, the cost of excavating adequate channels is often prohibitive, and dikes or levees are constructed to contain flood flows within the river channel. When the velocity of flow in a stream is more than a few feet per second, depending on the soil, bank and channel bottom erosion can cause disastrous changes in channel alignment, and erosion control measures become necessary. The most commonly employed bank protection, or revetment, is rock rip-rap, though numerous other measures ranging from revetment fences to concrete paving are employed. Bottom stabilization measures include check dams and rock blankets. When the gradients of channels become hydraulically steep, that is greater than about 0.5%, full concrete lining is often necessary. In addition to providing excellent erosion control concrete lining is smooth and the reduced friction results in higher velocities which permit smaller channel cross-section, which in turn reduces right-of-way requirements.

A plan of improvement of streams in and near the airport has been proposed by the U.S. Army Corps of Engineers in response to a request by the Santa Barbara County Flood Control and Water Conservation District. It is proposed to widen and deepen the lower reaches of the channels and to protect the banks with rock rip-rap. The reaches immediately upstream would be concrete lined. Plate X shows the scope of the improvements.

The Flood Control District with the cooperation of the Soil Conservation District has embarked on a long term project for protecting the banks of the natural channels above the Corps work. Generally pipe and wire or sacked concrete revetment and some check dams are proposed.

The Flood Control District and the County of Santa Barbara have been acquiring rights-of-way from developers as the land has been divided. For the last few years green areas along the creeks have also been obtained, all at no cost to the public agencies. In this way, encroachment on the stream channels has been largely prevented and aesthetic values preserved. County policy now calls for public streets to be placed adjacent to the green areas, which enhances access to the streams. The County Road Department has been very cooperative in constructing bridges of adequate waterway area across stream channels.

The Flood Control District also has plans for providing increased capacity in the reaches of streams which are inadequate but not included in the Corps of Engineers plans. The District keeps channels cleared of growth, debris, and silt, which would obstruct the flow of water, under an extensive maintenance program.

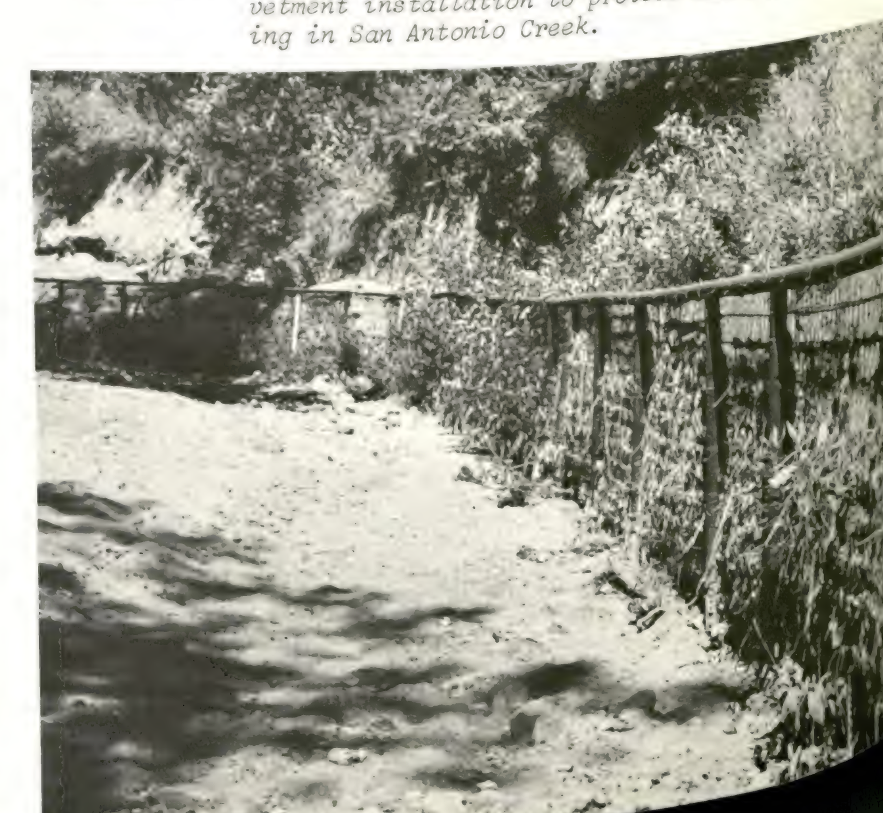
Storm Drains. Underground structures for the conveyance of flood and storm waters are called storm drains. In California practice, the term "sewers" is used for structures carrying sanitary wastes either separately or combined with storm runoff. It is customary to enclose small drainage ways in urban areas in storm drains. In areas of high land values, some fairly large watercourses are routed through underground structures. The limiting size between open channels and storm drains is usually determined by engineering economic studies, including the costs of rights-of-ways. Street inlets, sometimes called catch basins, are a very important part of any storm drain system. The available techniques for the hydraulic design of street inlets are not as precise as might be desired, and in addition, certain types of inlets are especially subject to clogging. As a result inlets are often the weakest link in a storm drain system. Experience has shown that grate type inlets should only be used in streets with longitudinal slopes exceeding about 2%. Curb opening inlets are preferred in sumps and on flatter slopes. Storm drain conduits usually consist of concrete pipe, concrete box structures, or corrugated metal pipe. Concrete structures are generally to be preferred because of their long life expectancy and low frictional resistance.

Many storm drains have been constructed in the Goleta Valley, principally by subdividers and developers with a few built

Photo 30. San Antonio Debris Dam constructed by U.S. Army Corps of Engineers following the Coyote Fire of 1964.

by the County Road Department. Flood Control District policy calls for all design flows which can be conveyed in a 48" pipe to be storm drained. Because of high land values, subdividers have elected to install pipes as large as 72" diameter. The Road Department and the Flood Control District have adopted as standard curb-opening inlets with streamlined entrances, but many older small grate type inlets continue to cause problems and should be replaced.

Photo 31. Flood Control District standard pipe and wire revetment installation to protect banks from eroding in San Antonio Creek.




GOLETA WATERSHED SURVEY
FLOOD HAZARD AREAS
DRAWN BY A. Meehan DATE 1966
ENGINEER Flood C. Staff DATE 1966
PLATE XI
LEGEND
AREAS SUBJECT TO INUNDATION BY CORPS OF ENGINEERS PROJECT FLOOD
BANK EROSION HAZARD
BRIDGES AND CULVERTS WITH INADEQUATE WATERWAY AREAS
AVERAGE WATER YEAR ISOHYETS (INCHES)
CREEKS
0 2000 4000
SCALE (FEET)
N
WATERSHED BOUNDARY
TECOLOTITO (GLEN ANNIE) CREEK
CARNEROS CREEK
TECOLOTITO CREEK
SAN PEDRO CREEK
LAS VEGAS CREEK
SAN JOSE CREEK
YGNACIA CREEK
SAN ANTONIO CREEK
MARIA YGNACIA
ATASCADERO CREEK
HOSPITAL CREEK
CIENEGUITAS CREEK
16"
18"
20"
22"
24"
26"
28"

Dams and Reservoirs. Dams may be constructed of just about any material which can hold water, and some which cannot. Conventional engineering construction includes concrete, earthfill, rockfill, inflatable rubber-fabric sausages, and, now infrequently, steel and timber. Economical flood control dams require large reservoir storage volumes for a given size of dam. Therefore, such dams are usually constructed in relatively flat river valleys. A major cost item of any dam is the spillway, which must be able to pass a very large flood without danger of the dam being washed out. The return period for spillway design floods may be 10,000 years for major dams, while much more frequent events are used for less important structures. Spillways take many forms, including overflow weirs, ski-jump spillways, siphons, conduits with and without vertical risers, gated and uncontrolled types, and so forth. As the consequences of dam failures are often catastrophic, the State of California closely supervises the design and construction of all but minor dams within the State.

Suitable economical sites for flood control reservoirs do not exist in the Goleta Watershed because of the steep terrain and high land values.

Debris Basins. A special type of dam and reservoir designed to trap sediment, boulders, trees, etc., is called a debris basin. Such structures are placed at the mouths of steep canyons in Southern California and elsewhere to trap solids in flood flows which would clog downstream bridges and channels. Debris basins are especially effective below burned watersheds.

A debris dam was built across San Antonio Creek above Tucker's Grove Park following the Coyote fire of 1964. Additional debris structures are proposed at the mouths of several canyons as part of the Corps of Engineers improvements.

Trash Racks. Devices to keep floating material out of storm drains and channels are called trash racks. They range in size from small, closely spaced bars to heavy steel piles on 8' centers. Smaller trash racks frequently clog themselves and defeat the purpose for which they were installed. This is especially true where the bars at the entrance to storm drains are closely spaced to try to exclude children. Experience has shown that children are seldom excluded, but trash is with such efficiency that clogging occurs. In certain installations, trash racks with larger dimensions have been invaluable in preventing complete plugging of bridges, culverts and channels.

3. NON-ENGINEERING MEASURES

This listing of flood control works would be incomplete without brief mention of some non-engineering measures. The most important of these fall under the category of watershed management through programs of the Soil Conservation Districts, the federal and state Soil Conservation Services, and the federal and state Forest Services. Basically, the objective of these programs is to maintain adequate vegetation on the watersheds to hold soil in place and minimize runoff. Among these activities are forest and brush fire control and reseeding burned watersheds.

Watershed Management. Watershed management requires a knowledge of topography, soils, vegetation, and land use; shape, size and arrangement of watershed and related subwatershed areas and the characteristics of drainage and stream channel flow. It is a composite of engineering and forestry practice that suitably integrates required overall land treatment measures with the needed supporting engineering or construction installations. Basically the objective of land treatment is to maintain adapted land use and vegetative improvement measures required to stabilize the physical relations between soils, vegetation and rainfall in the watershed areas. Improved infiltration, reduction of runoff, erosion, flood and debris are the products of these operations.

Rural and Urban Lands. Most farms and ranches in the Goleta Watershed follow recommended practices to minimize soil erosion. The U.S. Forest Service manages the upper watersheds and needs additional funds for expanded fire control measures. The Santa Barbara County Grading Department administers the County grading ordinance which calls for slope planting, interceptor drains, downdrains, and other measures which help minimize erosion on construction sites. Even with these measures, erosion in new subdivisions is often severe until all houses are occupied and full planting established.

Forest Service Lands. The primary values of these lands within the National Forest are water supply, recreation and maintenance of wildlife habitat. National Forest management direction provides for the development and maintenance of vegetation and soil conditions that will insure a high quality watershed, a desirably esthetic backdrop for the south coast and simple mountain recreation for hikers, horseback riders and picnickers.

These lands are significant in the flood control problem because they occupy the areas of rugged topography, receive the greatest precipitation and contribute most of the runoff. They also supply most of the water for the recharge of storage basins.

Photo 32. Tecolote Creek, November, 1965. Note tree trunks and logs above trash rack. This facility prevented the plugging of the culvert under Highway 101, which would have caused the flooding of the subdivision in the canyon upstream.

Normal or geologic erosion rates are low within the watershed, however, when the protective vegetation is removed by wildfire the exposed soil mantle is susceptible to accelerated erosion. The problem of accelerated erosion from watershed lands is important because the clogging of stream channels tends to bulk flood flows, inundate lowland areas and accumulate in reservoirs. Surface runn-off is increased and stream flow peaks become much greater than from slopes covered with vegetation.

National Forest Management Practices. The following National Forest management practices are intended to maintain and enhance the primary watershed values:

1. Maintain desirable vegetative cover through fire protection and cover manipulation.
2. Provide engineering measures to control stream flow, erosion and siltation.
3. Develop recreation potential through construction of riding and hiking trails, overlook points, picnic areas and other simple recreation features.
4. Develop wildlife potential through construction of water developments and browse ways.
5. Maintain esthetic appearance.
6. Eliminate uses inimical to primary values.

Fire Protection Needs. Watersheds which discharge into intensively developed areas where flood damage potential is great should receive intensive protection against fire. The following items are needed to meet this objective:

1. Increase the number of personnel.
2. Establish a station within the watershed area.
3. Equip station with tanker.
4. Build additional access roads.
5. Construct additional fuelbreaks down all major ridges.
6. Increase number of catchment tanks in the area.
7. Increase number of Fire Prevention Technicians in the area.
8. Conduct hazard reduction along all roads.
9. Employ the use of helicopters and air tankers.

The lack of sufficient interior roads hamper fire control personnel in their attempt to meet minimum 15 minute initial attack standards. Only five percent of the total area within the National Forest boundary can be reached within this period by vehicular travel. Plate XII shows facilities required for improved fire control in the forest areas in the Goleta Watershed.

GOLETA WATERSHED SURVEY

NATIONAL FOREST
FIRE CONTROL NEEDS

DRAWN BY E. J. Rix DATE 1966
ENGINEER U.S. Forest S. DATE 1966

PLATE XII

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

1. Local government agencies should continue to protect stream channels from encroachment and should protect aesthetic and conservation values by acquiring greenbelts along major streams in the Goleta Watershed as land develops. The present policy of placing public streets adjacent to such greenbelts should be continued.

2. Land developers and subdividers should continue to be required to construct full drainage improvements through their developments. If this policy is applied consistently, complete drainage systems will be developed with minimal expenditure of tax funds.

3. Increased efforts should be made to reduce the risk of disastrous brush fires in the watersheds above the Goleta Valley in order to decrease the threat of flash flooding and to minimize direct fire damage to improvements.

4. The successful program of soil conservation practices on farms and ranches should be continued to protect irreplaceable soil resources and to keep erosion and sediment production at a minimum. Farm plans should be coordinated with watershed management needs.

5. The present program of constructing revetments in badly eroding reaches of streams should be continued to minimize sediment production which contributes to the silting of creek beds and to protect property.

6. Grading controls should be strictly enforced to insure mulching and planting of fresh banks, installation of proper local drainage devices, and to avoid extensive grading in unstable areas.

7. The proposed plan of flood control improvements by the U.S. Army Corps of Engineers for the Goleta Watershed is endorsed. The provision of debris barriers at the mouths of major canyons is urged.

8. The expanding program of acquiring basic hydrologic data, including recording raingages and streamgages, should be continued to permit a continued improvement in the hydrologic techniques developed as part of the AB1144 Watershed Survey.

9. Present weather forecasts for the Santa Barbara-Goleta area are inadequate and should be vastly improved. Improved forecasts of high intensity rainfall are needed to enable more effective flood fighting measures to be taken. The danger of the Santana type of weather should be properly recognized and much better forecasting is needed in order to set up proper fire control measures and to warn the inhabitants adequately of the possibility of dangerously high winds and/or atmospheric temperatures.

10. The Land Use Capability System of land classification provides a highly refined guide for suitable recommended use of agricultural and watershed wildlands. Users of these lands should tailor their conservation practices to conform with or improve the designated Capability Classification. The planting of closely spaced tree crops such as citrus and avocados on terraced Class VI and VII lands should be encouraged in order to minimize runoff, erosion and flood hazards from these areas.

11. Detailed soils and geologic information and knowledge should be secured to properly appraise site location problems and improvements. Conformance with grading ordinances and related recommendations will thereby be expedited with minimum risks of site safety.

12. The land use recommendations in the General Plan for Santa Barbara County will require revision at regular intervals to reflect forecasted socio-economic change. The current plan is in need of revision. A three to seven year interval is suggested for future revisions.

13. As with the revision of the General Plan, the Goleta Watershed Comprehensive Soil and Water Conservation Planning Project Report will require updating to accommodate change and refinement in related basic data as the latter is affected or modified by change in land and water resources use in the area. A five year interval is recommended for review and revision.

(2) Correlations and practice recommendations

e. Effect of coordination of planning information and data on programming for
   (1) Soil Conservation
   (2) Water Conservation
   (3) Flood Control and drainage
   (4) Land use
      (a) Agricultural lands
      (b) Rural and urban developments
      (c) Watershed-wildlands
      (d) Other
   (5) Recreational developments
   (6) Other community or public improvements

VII. PROJECT REPORT

A. Editorial responsibility

B. Table of contents

C. Text and maps

D. Review and approvals

E. Publication

APPENDIX 3

GOLETA WATERSHED COMPREHENSIVE CONSERVATION PLANNING PROJECT

PROCEDURAL PLAN

A tentative procedural plan covering the proposed four year period of project operations was developed as follows:

First Year (1961-62) (Funds Granted)

1. Collection and inventory of available subject matter reports and technical information and data based on "Comprehensive Outline" guide segregations.

2. Selection of a technical advisory coordinating committee for the appraisal and analysis of all collected information and data. Determination of service provisions and/or contract and consultation fees.

3. Preparation of base maps for inventorying, planning and investigational recording and analysis, covering watershed and sub-watershed areas.

4. Appraisal and analysis of collected and inventoried data and information; mapping and recording of selected items.

5. Determination of local cost-sharing contributions, and jurisdiction of fund sharing allocations.

6. Preparation of budget.

7. Initiation of field surveys, technical studies and investigations; viz:
   (a) Soils, Conservation, Land-use
   (b) Geological
   (c) Hydrological and Engineering

8. Progress report.

Second Year (1962-63) (Funds Allocated)

1. Continuation of first years phases uncompleted.

2. Determination of additional information and data required including field surveys, comprehensive studies and investigations needed to complete (a) minimum and (b) maximum levels of planning for project objectives.

3. Appraisal and analysis of information and data.

4. Preparation of budget.

5. Progress report.

Third Year (1963-64)

1. Continuation of first and second years schedule and operations.

2. Preparation of preliminary sectional reports in accordance with the "Outline" guide.

3. Preparation of budget.

4. Progress report.

Fourth Year (1964-65)

1. Completion of field surveys, technical studies and investigations.

2. Completion of analysis of data and information.

3. Completion of mapping and records.

4. Preparation of budget.

5. Preparation of final report.

APPENDIX 4

LOG OF RAINFALL AND ITS EFFECTS IN SANTA BARBARA AREA DURING STORMS OF JANUARY, 1914

(Abstracted from files of Santa Barbara News-Press)

January 2 — Rainfall past week, 2 inches; Season total 6.87 inches.

January 3 — Drizzle, new storm appearing just as previous one ending.

January 15 — Storm precipitation, 0.59 inches; Season total 7.55 inches.

January 16 — Storm precipitation, 1.90 inches (2.71 inches at San Marcos Pass).

January 17 — Storm precipitation, 2.73 inches; Season total 9.73 inches.

January 18 — Rain during previous night believed about 3 inches. Continuous, heavy at times. Strong southeast wind. Old timers claim most severe in 15 years. No street lights. Five small craft sunk or blown onto beach or pier supports. Mission Creek going over Chapala Street bridge. Train service curtailed because of washouts and slides north of Santa Barbara.
Forecast of new storm due today.

January 20 — Storm by early January 18, 1914 totalled 3.36 inches; Season total 12.86 inches. Very warm rain. Many thousands of dollars damage to waterfront, 200,000 feet of lumber lost to sea.
Trains again running.
Carpinteria well drained, with little rain damage but some wind damage.

January 23 — "Terrific" storm in central California.

January 25 — Season total rain over 15 inches, 20.87 inches at San Marcos Pass.

January 26 (Monday)
Storm totaled 8.48 inches from Friday midnight to Sunday night, the most severe being a little over 4 inches in 2 hours on Sunday afternoon. Season total at 22.45 inches. January rainfall of 16.91 inches, greatest in 41 years. Barometer dropped to 29.60. Already well filled streams flooded by heavy rains from Ellwood to Rincon.
Two people drowned in Montecito Creek.
Mission Creek overflowed, crossed Hollister Ave., pouring through broad spread of properties, tearing out fences and small buildings. A few homes washed away, other twisted on foundations.
Flood 2000 feet wide in vicinity of Cottage Hospital.
Trains stalled in Santa Barbara and 175 passengers to be removed by steamer. Resumption of service promised February 6th. Paved roads held up well in Montecito and Goleta districts except when hit sidewise by floods. Olive Mill Road in Montecito destroyed and 20 feet deep in places. Deep gulches cut in gently sloping lands. Ten foot gulches cut

continued

in Cabrillo Boulevard.
On Ellwood Cooper ranch, much damage from trees washing downstream. Fifteen Bridges washed out.
Similar devastation in canyons of the Goleta-Naples district. Considerable damage to orchards in Stow Canyon.
In lower valley, between Goleta and Corona Del Mar, ground covered with 1 to 3 feet of muck, the paved road (Hollister Ave.) being buried for distances of more than a mile. Carpinteria roads also covered with muck.

Photo 33. Hollister Avenue bridge over Maria Ygnacia Creek, January, 1914. This damaged bridge was rebuilt and remained in service until Hollister Avenue was widened in 1964.

APPENDIX 5

DESCRIPTION OF SOIL SERIES OF THE GOLETA WATERSHED AREA, SANTA BARBARA, CALIFORNIA

(Abridged from: "Soil Survey Santa Barbara Area California": U.S. Dept. of Agriculture in Cooperation with University of California Agricultural Experiment Station March, 1958).

AGUEDA

The Agueda series is made up of recent alluvial soils of uniform profile. The parent material has washed mainly from Zaca and Nacimiento soils. The soils occur mostly on narrow stream bottoms and alluvial fans along some of the creeks. Some of the soils contain gravel.

The surface soil is dark gray, moderately calcareous, and of moderately fine texture. It is friable when moist. The structure is weak or indistinct when the soil is dry. This layer is moderately permeable to moisture and has a high waterholding capacity.

The subsoil is dark gray, calcareous, similar to the surface soil in texture, and friable and easily crumbled when moist. It has both disseminated and segregated lime.

The parent materials are stratified and usually of moderately fine texture. They are calcareous, of grayish color, and massive.

ALISO

Soils of the Aliso series have well-defined claypan subsoil layers and occupy low undulating terraces that fringe the upper parts of the Goleta Valley. The soils have formed in old alluvial deposit. Aliso soils are closely associated with Milpitas soils but are more reddish and do not have so compact a subsoil.

The surface soil is brown, slightly acid or neutral, and granular under virgin conditions. The upper subsoil is reddish-brown, very hard, noncalcareous, prismatic clay. The structural aggregates are roughly twice as long as they are broad and are heavily coated with colloids.

The lower subsoil is brown, slightly calcareous, blocky clay loam or clay. It is not so compact as the upper subsoil and has some soft nodules of lime.

The parent material is brown, stratified, and of medium texture. In general the material is massive and somewhat compact. These soils are subject to considerable sheet erosion.

ALVISO

Soils of the Alviso series have formed under the influences of a very high water table. They adjoin Tidal marsh and are only a foot or two above sea level. The water is strongly saline; consequently, the soils have strong concentrations of soluble salts. The high water table and salinity have prevented formation of distinct profile characteristics. The soils occur as a fringe at the lower edges of the Goleta Valley.

The surface soil is gray and medium to fine texture. A few small areas do have a sand surface soil. The surface soil is slightly calcareous and mottled with rust-brown iron stains and dark-colored organic matter. The underlying material is stratified, slightly calcareous, and of variable texture, and has light gray iron stains caused by the constant high water table.

BAYWOOD

The Baywood series consists of soils with weakly defined profile layers. They have formed on windblown deposits that occupy terraces in many places along the coast.

The surface soil is grayish-brown, single-grained loamy sand or loamy fine sand. The upper 2 or 3 inches is slightly darker than the rest of the layer. The reaction is medium acid. The subsoil consists of grayish-brown material similar to the surface soil in texture but slightly compact. The reaction is medium acid. The underlying parent materials are loose light yellowish-brown sands or loamy sands and are medium acid in reaction.

Some areas of these soils have only a thin layer of sandy material over the old terraces on which Milpitas, Watsonville, or other soils have developed.

BOTELLA

Soils of the Botella series have formed on slightly older alluvial fans and flood plains, usually along narrow valleys cutting through soils of the terraces or uplands. The surface soil is a granular dark-gray neutral clay loam. The subsoil is dark-gray, neutral, slightly finer textured than the surface soil, and slightly compact. The structure is subangular blocky, the aggregates are hard and have a small amount of colloid on their surfaces.

The parent material is grayish-brown, stratified, neutral to slightly basic, noncalcareous, and of variable but usually moderately fine texture. This material is softer than that of the subsoil.

Botella soils are highly productive and suited to a wide range of crops.

CARPINTERIA

The Clear Lake soil is at the lower edges of alluvial fans and in interfan areas. It has formed in nearly level areas close to the sea where drainage water accumulates. Drainage is poor. Water stands on the surface during the rainy season. The water table is so high that water moves upward during the dry season.

The surface soil is a black, neutral clay of coarse or very coarse blocky structure. It is very hard when dry and when wet it is sticky and plastic. The upper subsoil is dark gray, slightly basic, and has a texture similar to or slightly finer

than that of the surface soil. Cracks extend down into this layer when the soil is dry. The aggregates are large, blocky, and thinly coated with colloidal stains. Some soft white nodules of lime are present throughout. The lower subsoil is dark grayish-brown and of somewhat variable texture. It is moderately calcareous and has many light-gray lime nodules. An appreciable amount of brownish iron mottling is apparent throughout.

The parent materials consist of moderately calcareous stratified layers that have a wide range in texture. There is considerable brownish iron mottling and some lime nodules.

Clear Lake soil, because of the high water table, must have artificial drainage before it can be used extensively for field crops. In this area the Clear Lake soil occurs so near sea level that adequate drainage is difficult to provide and to maintain. Some areas have saline salts in concentrations that reduce plant growth.

COASTAL BEACH

Coastal Beach, sandy. These narrow sandy beaches are covered or nearly covered by waves during high tide and exposed during low tide. Along parts of the coast, bluffs 10 to 50 feet in height are back of the narrow beaches or rise abruptly from the sea. The beaches have no agricultural value but are used for recreation.

Coastal Beach, stony. These stretches of coastal beach occur mainly at the mouths of streams that cross the narrowest part of the coastal plain, where well-rounded stones are deposited. These stony beaches are not so desirable for recreation as the sandy beaches. Coastal beaches are not stable; they may change from sandy to stony, or the reverse, during storms.

GAVIOTA

The soils of the Gaviota series are shallow over hard, light-colored Vaqueros sandstone of the Lower Miocene age. In places where the profile is slightly deeper than normal, the subsoil has a slight accumulation of clay. The soils occur in narrow bands that parallel the coast. Much of the area of Gaviota soils is steep and very steep.

The surface soil is brown, slightly hard, slightly to moderately acid sandy loam or fine sandy loam. This layer is very friable when moist and has a granular structure. The subsoil is light yellowish-brown and has about the same texture as the surface layer. It is slightly hard, and, except for its lighter color, is much like the surface soil. Where the soil profile is deeper than normal, the subsoil has a finer texture and occasionally shows a thin clay layer just above the bedrock. The reaction throughout is slightly to moderately acid.

The parent material is pale-brown sandstone. In most areas the sandstone is hard and has only a thin zone of weathering above the massive rock.

Kitchen middens, over permeable soil materials. This miscellaneous land type consists of areas where the Indians made campgrounds on permeable recent soil materials. The campgrounds are darker in color than the surrounding soil, calcareous, and contain shell fragments. In some places these campsites appear as mounds, but in others they are at about the same level as the surrounding soil. In all places the soil material is more friable when moist than that of the surrounding soils, and is not so easily puddled. Where they occur on alluvial soils and are cultivated, these middens usually produce as well as the surrounding soil, or sometimes better.

LANDSLIP

These miscellaneous land types are the result of a specialized type or erosion. Large quantities of soil and its parent material have moved down the slope by the force of gravity. Although these soils were originally members of various soil series of the area, the slipping action tends to mix and distort the profile layers. Soils are particularly unstable and likely to slide in zones of transition from one type of parent material to another. This weakness is more apparent when the soil material is wet.

LOS OSOS

Soils of the Los Osos series rest on bedrock of shale or clayey sandstone. They occupy sloping to very steep areas where ridgetops are rounded and slopes are smooth. The Los Osos surface soil is gray, slightly acid, blocky, and of moderately fine to fine texture. The moderately fine textures predominate. The subsoil is dark grayish-brown, neutral to slightly basic, and of finer texture than the surface soil. This layer is compact and of blocky structure. The aggregates are coated with colloidal materials. In some locations the subsoil is intermittently calcareous.

The parent materials are olive-gray shales or clayey sandstones. The upper part is weathered and crumbled and intermixed with soil materials. The material becomes more massive with depth. Los Osos soils are used mostly for range. They have good grazing capacity.

MAYMEN

Soils of the Maymen series occur mostly in rough mountainous area where ridges are sharp and there are many rock outcrops. The soils are shallow to moderately deep and have little or no profile development. The natural vegetation is mostly brush. The surface soil is brown, soft, slightly to medium acid, and sandy. It is very friable when moist and has a weak granular structure. Appreciable amounts of sandstone fragments are on the surface and imbedded in the soil. The subsoil is very pale brown and medium acid; otherwise it is similar to the surface soil. The parent material is weathered pale yellow sandstone and is usually at shallow depths. Below it is hard massive sandstone, principally the Tejon formation of Eocene age.

MILPITAS

The soils of the Milpitas series have formed on old terraces along the coastal plain. They occupy low or medium, rolling or gently undulating terraces that are dissected in many places by small creek channels. The surface soil is brown, slightly to medium acid, granular fine sandy loam. Just above the claypan subsoil this surface layer has a thin light-gray horizon with a pronounced visicular porosity. The subsoil is yellowish-brown compact clay, slightly to medium acid in reaction. The upper part of this layer has a definite prismatic structure when dry. The prismatic aggregates, about twice as long as they are broad, are heavily coated with collodial stains. The lower subsoil is a blocky clay. The aggregates of this clay are somewhat less compact and less heavily coated with collodial material than those in the upper part of the subsoil.

Soils of the Milpitas series have developed through the weathering of light yellowish-brown, stratified, variably textured, moderately compact old alluvial material of sedimentary origin. The soils are subject to erosion, particularly gullying.

MOCHO

Soils of the Mocho series occur on smooth gently sloping alluvial fans and flood plains, fairly close to stream channels. The surface soils are brown, slightly hard, and slightly calcareous; they range in texture from loamy sand to loam. The underlying materials are stratified brown to pale brown calcareous and of wide range in texture. They are very friable when moist and are easily penetrated by roots and water. These soils are suited to most crops climatically adapted to the area. They produce high yields of wide variety of crops.

MONTEZUMA

The Montezuma series consists of fine-textured soils on old low terraces of rolling relief. The surface soils are very dark gray, hard, noncalcareous, and generally of clay texture. A few areas are clay loam. The surface layers develop an adobe structure of large blocks with wide shrinkage cracks. These large blocks break further along secondary cracks to a finer blocky structure.

The subsoils are dark gray, slightly calcareous compact claypan in the upper part, but are lighter in color and more calcareous with depth. The wide surface cracks extend through this material, but there is no secondary cracking. When the subsoil is dry, it develops a coarse blocky structure. It is hard when dry and very sticky when wet. Parent materials consist of grayish-brown clay loam or clay that is usually noncalcareous. Drainage is slow because of the fine texture and compact subsoil.

NACIMIENTO

Soils of the Nacimiento series have formed over soft calcareous shale bedrock. The soils are sloping to very steep and have well rounded crests and smooth slopes. The soils occur near the coast. They are somewhat like the Zaca soils. Both the Nacimiento and Zaca soils formed over bedrock of the Rincon geological formation, but on parent rock different in color and mineralogical characteristics. The profiles are relatively deep for residual soils, and the underlying bedrock is easily weathered.

The Nacimiento surface soils are dark grayish-brown, slightly calcareous, and mostly of clay texture, although a few areas are of clay loam. The soils tend to crack but do not have a pronounced blocky (adobe) structure like that of the Montezuma soils. They are friable when moist and break easily to a finer blocky structure. The subsoils are light olive-gray clay. They are moderately calcareous, and some lime is segregated in soft seams or nodules. This horizon appears mottled because the soft well-weathered shale fragments show brownish iron stains.

The parent material is light olive-gray, soft, slightly calcareous shale. Considerable soil material and segregated lime are intermixed with the upper part, but these decrease with depth. The shales remain soft to a considerable depth.

ROUGH BROKEN AND STONY LAND, GAVIOTA SOIL MATERIAL

This miscellaneous land type has outcroppings of sandstone rock over 60 percent or more of the surface. The soil material between the rock outcrops is like that of the Gaviota soils but is very shallow.

ROUGH BROKEN AND STONY LAND, MAYMEN SOIL MATERIAL

This miscellaneous land type has outcroppings of sandstone and shale bedrock on 60 percent or more of the surface. The material between the rocks is like that of the Maymen soils but is very shallow and stony.

ROUGH BROKEN AND STONY LAND, SESPE SOIL MATERIAL

More than 60 percent of the surface of this miscellaneous land type consists of outcroppings of shale or sandstone rock of the Sespe geologic formation. The material between the rock outcrops is like that of the Sespe soils but is very shallow and often stony. This land type is moderately extensive and occurs on steep slopes just below areas of rough broken and stony land, Maymen soil material. It has a denser brush cover than that land type and furnishes slightly better range.

SAN ANDREAS

The soils of the San Andreas series have developed from softly consolidated sandstones of the Santa Barbara formation. They occupy hilly to steep areas on smooth slopes and well-rounded ridgetops. They are closely associated with soils of the Tierra series.

The surface soils are grayish-brown, soft, granular, medium acid loamy sand to find sandy loam. Under natural vegetation, the color may be considerably darker than it is in cultivated areas. The subsoils are light brownish-gray, loose, single grained, medium acid loamy sands. Where there is a little more clay, the subsoil is slightly compact. The clay layers seem to develop where the soft sandstone provides clayey material.

The parent material is light-gray massive sandstone that is softly consolidated to considerable depths so that both roots and water penetrate freely.

SESPE

Soils of the Sespe series rest on shale bedrock of the Sespe formation, a continental (nonmarine) formation of Oligocene age. The soils are hilly to very steep and generally are next to but lower in elevation than the Maymen soils.

The surface soils are brown to dark-brown, neutral to slightly acid clay loams and clays. Under virgin conditions they are friable when moist and have a granular structure. The upper subsoils are dark-brown to dark reddish-brown, hard, neutral, subangular blocky clay loams or clays. The aggregates have some colloidal coating on the surfaces. The lower subsoils are moderately basic; they contain lime in both disseminated and segregated form.

The parent material is light brownish-gray, hard shale or clayey sandstone bedrock, somewhat shattered and crumbled in the upper part, and mixed with considerable lime and soil. The shale becomes massive and harder with depth. In some places, strata of shale are interbedded with thin layers of sandstone.

SORRENTO

The soils of the Sorrento series were derived from alluvium. They occur on smooth gently sloping recent alluvial fans and narrow flood plains. The surface soils are dark grayish-brown, neutral to slightly basic, and vary from loamy sands to loam. They are very friable to friable when moist, and easily worked.

The subsoils are pale brown, slightly calcareous, moderately basic, and similar to the surface soil in texture. Roots and water easily penetrate. Lime occurs in both disseminated and thin threadline forms. It is stratified in places. The parent material is similar to the subsoil but slightly lighter in color and slightly more basic in reaction. It is somewhat stratified but does not vary a great deal in texture.

TIDAL MARSH

Tidal marsh consists of swampy areas along the coast, mainly at mouths of steams. They are nearly covered by sea water during high tides and almost completely exposed at low tide. This land has no agricultural use.

TIERRA

The soils of the Tierra series have claypan subsoils that rest on semiconsolidated old terrace material. They occupy high coastal plain terraces that have rolling tops and steep escarpments. These soils are especially susceptible to gully erosion. Many large fullies have cut deeply into the underlying parent material.

The surface soil, a dark-gray medium to strongly acid fine sandy loam, is friable when moist. The lower part of the layer, just above the claypan, is gray and strongly leached. The subsoil is gray, medium acid, blocky clay. The aggregates are heavily coated with colloidal materials and are very hard when dry. The parent material is grayish-brown, stratified, semiconsolidated marine sediments of medium to fine texture.

WATSONVILLE

Soils of the Watsonville series have claypan subsoils that rest on the unconsolidated material of low marine terraces. The terrace tops are smooth and rolling or undulating and generally break abruptly to steep terrace escarpments. These soils occur close to the ocean along the coastal plain.

The surface soil is dark-gray, hard, medium acid sandy loam to loam, very friable to friable when moist, and weakly granular. It puddles easily if worked or pastured when too wet. The 3 or 4 inches just above the claypan is light gray and distinctly vesicular.

The subsoil is dark-gray to dark grayish-brown, very hard, medium acid, compact clay. The upper subsoil is distinctly prismatic, and the lower part tends to be blocky. The aggregates are heavily coated with colloids and inside they are often mottled brownish and grayish. The parent material is gray, hard, massive, medium acid sandy clay loam to sandy clay.

YOLO

Soils of the Yolo series occur on nearly level to sloping recent alluvial fans. They are similar to and closely associated with soils of the Sorrento series. The surface soil is dark-gray neutral sandy loam or loam. It has a weak granular structure. The subsoil is dark grayish-brown and neutral, and similar to the subsoil but more highly stratified.

Yolo soils in this area are in general slightly darker colored than the associated Sorrento soils. Yolo soils are used for and are suited to a wide variety of crops.

ZACA

The soils of the Zaca series rest on soft calcareous shales. The slopes range from hilly to very steep, are smooth, and have well-rounded crests.

The surface soil is very dark gray, moderately basic, moderately calcareous clay loam and clay. In places it is shaly. The structure is weakly blocky. Despite the fine texture, the soil is usually porous and easily crumbled.

The subsoil is dark-gray, moderately basic, moderately calcareous, and of subangular blocky structure. Lime occurs mostly in the form of soft seams and nodules. This layer contains a few fragments of shale; the number increases with the depth.

The parent material consists of pale-yellow, massive, strongly calcareous shale. This shale is soft and deeply weathered, and a little soil material is intermixed with it. The upper part is somewhat mottled with brownish iron stains.

TABLE OF SOIL CHARACTERISTICS AND INTERPRETATIONS OF THE GOLETA VALLEY

Map Sym.	Soil Name	Cap Unit	Position	SOIL PROFILE: Surface Layer	SOIL PROFILE: Subsoil	SOIL PROFILE: Substratum or Parent Mtl.	Rocks and Stones	Shrink-Swell Potential	Septic Tank Filter Fields	Slippage	Drainage	Soil Index
Aa	Agueda clay loam, gently sloping	IIe5	Stream bottoms and alluvial fans	Dark gray, granular, hard, calcareous	Dark gray clay loam, granular, hard, calcareous	Gray clay loam, massive, hard, calcareous	Slight	Moderate	Moderate	Low	Well	81
Ab	Agueda clay loam, nearly level	I	Stream bottoms and alluvial fans	Dark gray, granular, hard, calcareous	Dark gray clay loam, granular, hard, calcareous	Gray clay loam, massive, hard, calcareous	Slight	Moderate	Moderate	Low	Well	85
Af	Aliso fine sandy loam, gently sloping, moderately eroded	IIIe3	Low terraces	Brown, granular, hard, slightly acid	Reddish brown clay, prismatic, very hard, neutral	Brown clay loam, blocky, hard, calcareous	Slight	Moderate	Severe	Low	Slow permeability	46
Ag	Aliso fine sandy loam moderately steep, moderately eroded	VIe3	Low terraces	Brown, granular, hard, slightly acid	Reddish brown clay, prismatic, very hard, neutral	Brown clay loam, blocky, hard, calcareous	Slight	Moderate	Severe	Low	Slow permeability	36
Ah	Aliso fine sandy loam, sloping	IVe3	Low terraces	Brown, granular, hard, slightly acid	Reddish brown clay, prismatic, very hard, neutral	Brown clay loam, blocky, hard, calcareous	Slight	Moderate	Severe	Low	Slow permeability	51
Ak	Aliso fine sandy loam, sloping, moderately eroded	IVe3	Low terraces	Brown, granular, hard, slightly acid	Reddish brown clay, prismatic, very hard, neutral	Brown clay loam, blocky, hard, calcareous	Slight	Moderate	Severe	Low	Slow permeability	36
Al	Aliso fine sandy loam, sloping, moderately eroded	VIIe1	Low terraces	Brown, granular, hard, slightly acid	Reddish brown clay, prismatic, very hard, neutral	Brown clay loam, blocky, hard, calcareous	Slight	Moderate	Severe	Low	Slow permeability	19
Am	Aliso loam, gently sloping, moderately eroded	IIIe3	Low terraces	Brown, granular, hard, slightly acid	Reddish brown clay, prismatic, very hard, neutral	Brown clay loam, blocky, hard, calcareous	Slight	Moderate	Severe	Low	Slow permeability	46
An	Aliso loam, moderately steep, moderately eroded	VIe3	Low terraces	Brown, granular, hard, slightly acid	Reddish brown clay, prismatic, very hard, neutral	Brown clay loam, blocky, hard, calcareous	Slight	Moderate	Severe	Low	Slow permeability	36
Ao	Aliso loam, moderately steep, severely eroded	VIIe1	Low terraces	Brown, granular, hard, slightly acid	Reddish brown clay, prismatic, very hard, neutral	Brown clay loam, blocky, hard, calcareous	Slight	Moderate	Severe	Low	Slow permeability	23
Ap	Aliso loam, sloping, moderately eroded	IVe3	Low terraces	Brown, granular, hard, slightly acid	Reddish brown clay, prismatic, very hard, neutral	Brown clay loam, blocky, hard, calcareous	Slight	Moderate	Severe	Low	Slow permeability	41
Ar	Alviso soils, undifferentiated, nearly level	VIIIw6	Low basins	Gray clay loam, massive, hard, slightly calcareous	Light brownish gray, mottled, stratified, calcareous, saline	Dull gray, mottled, stratified, calcareous, saline	Slight	High	Severe	Low	Poor	3
Ba	Ballard fine sandy loam, gently sloping	IIe3	Stream benches	Grayish brown, granular, hard slightly acid	Brown gravelly loam, blocky, hard, slightly acid	Yellowish brown gravelly loam, massive, slightly hard, slightly acid	Slight	Low	Slight	Low	Well	76
Bb	Ballard fine sandy loam, nearly level	I-3	Stream benches	Grayish brown, granular, hard, slightly acid	Brown gravelly loam, blocky, hard, slightly acid	Yellowish brown gravelly loam, massive, slightly hard, slightly acid	Slight	Low	Slight	Low	Well	80
Bc	Ballard fine sandy loam, sloping	IIIe1	Stream benches	Grayish brown, granular, hard, slightly acid	Brown gravelly loam, blocky, hard, slightly acid	Yellowish brown gravelly loam, massive, slightly hard, slightly acid	Slight	Low	Moderate	Low	Well	68
Bd	Ballard fine sandy loam, sloping, moderately eroded	IIIe1	Stream benches	Grayish brown, granular, hard, slightly acid	Brown gravelly loam, blocky, hard slightly acid	Yellowish brown gravelly loam, massive, slightly hard, slightly acid	Slight	Low	Moderate	Low	Well	48
Be	Ballard gravelly fine sandy loam, gently sloping	IIe1	Stream benches	Grayish brown, granular, hard, slightly acid	Brown gravelly loam, blocky, hard, slightly acid	Yellowish brown gravelly loam, massive, slightly hard, slightly acid	Slight	Low	Slight	Low	Well	53
Bf	Ballard stony fine sandy loam, gently sloping and sloping	VIs7	Stream benches	Grayish brown, granular, hard, slightly acid	Brown stony loam, blocky, hard, slightly acid	Yellowish brown stony loam, massive, slightly hard, slightly acid	Moderate	Low	Slight	Low	Well	29
Bg	Baywood loamy fine sand, gently sloping	IIIs4	Wind blown terraces	Grayish brown, single grain, loose, medium acid	Pale brown loamy fine sand, single grain, loose, medium acid	Yellowish brown loamy sand, single grain, loose, medium acid	Slight	Low	Slight	Low	Well	72
Bh	Baywood loamy fine sand, moderately steep	VIe1	Wind blown terraces	Grayish brown, single grain, loose, medium acid	Pale brown loamy fine sand, single grain, loose, medium acid	Yellowish brown loamy sand, single grain, loose, medium acid	Slight	Low	Moderate	Low	Well	57
Bk	Baywood loamy fine sand over Watsonville soils, gently sloping	IIIe3	Wind blown terraces	Grayish brown, single grain, loose, medium acid	Pale brown loamy fine sand, single grain, loose, medium acid	Dark gray clay, prismatic, hard, medium acid	Slight	Moderate	Severe	Low	Slow permeability	53
Bl	Baywood loamy sand, gently sloping	IIIs4	Wind blown terraces	Grayish brown, single grain, loose, medium acid	Pale brown loamy sand, single grain, loose, medium acid	Yellowish brown sand, single grain, loose, medium acid	Slight	Low	Slight	Low	Well	63
Bm	Baywood loamy sand, nearly level	IIIs4	Wind blown terraces	Grayish brown, single grain, loose, medium acid	Pale brown loamy sand, single grain, loose, medium acid	Yellowish brown sand, single grain, loose, medium acid	Slight	Low	Slight	Low	Well	66
Bn	Baywood loamy sand over Watsonville soils, gently sloping	IIIe3	Wind blown terraces	Grayish brown, single grain, loose, medium acid	Pale brown loamy sand, single grain, loose, medium acid	Dark gray clay, prismatic, very hard, medium acid	Slight	Moderate	Severe	Low	Slow permeability	47
Bo	Baywood loamy sand over Watsonville soils, nearly level	IIIs3	Wind blown terraces	Grayish brown, single grain, loose, medium acid	Pale brown loamy sand, single grain, loose, medium acid	Dark gray clay, prismatic, very hard, medium acid	Slight	Moderate	Severe	Low	Slow permeability	49
Bp	Baywood loamy sand, rolling	IVs4	Wind blown terraces	Grayish brown, single grain, loose, medium acid	Pale brown loamy sand, single grain, loose, medium acid	Yellowish brown sand, single grain, loose, medium acid	Slight	Low	Slight	Low	Well	57
Br	Botella clay loam, gently sloping	IIe5	Older alluvial fans and flood plains	Dark gray, granular, hard, neutral	Dark gray heavy clay loam, blocky, hard, neutral	Grayish brown clay loam, stratified, massive, hard, neutral	Slight	Moderate	Moderate	Low	Well	77
Bs	Botella clay loam, nearly level	I	Older alluvial fans and flood plains	Dark gray, granular, hard, neutral	Dark gray heavy clay loam, blocky, hard, neutral	Grayish brown clay loam, stratified, massive, hard, neutral	Slight	Moderate	Moderate	Low	Well	81
Ca	Carpinteria clay loam, gently sloping	IIe5	Older alluvial fans	Dark grayish brown, granular, hard, neutral	Dark grayish brown light clay, blocky, hard, neutral	Dark brown clay loam, massive, hard, moderately alkaline	Slight	Moderate	Moderate	Low	Well	77
Cb	Carpinteria clay loam, moderately steep	IVe5	Older alluvial fans	Dark grayish brown, granular, hard, neutral	Dark grayish brown light clay, blocky, hard, neutral	Dark brown clay loam, massive, hard, moderately alkaline	Slight	Moderate	Severe	Moderate	Well	61
Cc	Carpinteria clay loam, sloping	IIIe5	Older alluvial fans	Dark grayish brown, granular, hard, neutral	Dark grayish brown light clay, blocky, hard, neutral	Dark brown clay loam, massive, hard, moderately alkaline	Slight	Moderate	Severe	Moderate	Well	69
Cd	Carpinteria loam, gently sloping	IIe1	Older alluvial fans	Dark grayish brown, granular, hard, neutral	Dark grayish brown clay loam, blocky, hard, neutral	Dark brown loam, massive, hard, moderately alkaline	Slight	Moderate	Moderate	Low	Well	90
Cg	Cayucos clay loam, hilly, moderately eroded	IVe5	Uplands	Dark gray, blocky, hard, neutral	Dark gray clay loam, blocky, hard, neutral	Gray, hard, massive, noncalcareous shale	Severe	Moderate	Severe	Moderate	Well	20
Cl	Clear Lake clay, nearly level	IIIw5	Basin	Black, coarse, blocky, very hard, neutral	Dark gray clay, coarse, blocky, very hard, neutral	Light brownish gray, stratified, massive, hard, calcareous	Slight	High	Severe	Low	Poor	34
Co	Coastal beach, sandy	VIIIw4	Beach	A sandy miscellaneous land type found along the sea coast.			Slight	Low	Severe	Low	Poor	2
Cp	Coastal beach, stony	VIIIw4	Beach	A stony miscellaneous land type found along the sea coast.			Moderate	Low	Severe	Low	Poor	2
De	Dune sand	VIIIw4	Sand dunes along coast	This miscellaneous land type consists of loose, shifting sand.			Slight	Low	Slight	Low	Well	2
Ea	Elder clay loam, gently sloping	IIe5	Narrow valleys and alluvial fans	Dark gray, granular, hard, slightly acid	Dark gray, clay loam, granular, hard, slightly acid	Grayish brown shaly clay loam, massive, hard, neutral	Slight	Moderate	Moderate	Low	Well	76
Ef	Excavated land	VIIIs1	——	This miscellaneous land type consists of areas where soil and rock material have been removed by excavation and mining.								
Ga	Gaviota fine sandy loam, hilly	VIe1	Uplands	Brown, granular, slightly hard, medium acid	Light yellowish brown fine sandy loam, massive, hard, medium acid	Very pale brown, hard sandstone	Severe	Low	Severe	Low	Well	30
Gb	Gaviota fine sandy loam, hilly, moderately eroded	VIe1	Uplands	Brown, granular, slightly hard, medium acid	Light yellowish brown fine sandy loam, massive, hard, medium acid	Very pale brown, hard sandstone	Severe	Low	Severe	Low	Well	21
Ge	Gaviota sandy loam, hilly	VIe1	Uplands	Brown, granular, slightly hard, medium acid	Light yellowish brown sandy loam, massive, hard, medium acid	Very pale brown, hard sandstone	Severe	Low	Severe	Low	Well	29
Gf	Gaviota sandy loam, sloping	IVe1	Uplands	Brown, granular, slightly hard, medium acid	Light yellowish brown sandy loam, massive, hard, medium acid	Very pale brown, hard sandstone	Severe	Low	Severe	Low	Well	32
Gg	Gaviota sandy loam, sloping, moderately eroded	IVe1	Uplands	Brown, granular, slightly hard, medium acid	Light yellowish brown sandy loam, massive, hard, medium acid	Very pale brown, hard sandstone	Severe	Low	Severe	Low	Well	23
Gh	Gaviota sandy loam, steep	VIIe1	Uplands	Brown, granular, slightly hard, medium acid	Light yellowish brown sandy loam, massive, hard, medium acid	Very pale brown, hard sandstone	Severe	Low	Severe	Low	Well	15
Gk	Gaviota stony soils, undifferentiated, steep and very steep	VIIIs1	Uplands	Brown, granular, slightly hard, medium acid	Light yellowish brown stony sandy loam, massive, hard, acid	Very pale brown, hard sandstone	Severe	Low	Severe	Low	Well	5
Ka	Kitchen middens over permeable soil materials	IIe1	Along streams and the coast	Very similar to adjacent soils but somewhat darker colored, calcareous and with shell fragments.			Slight	Low	Slight	Low	Well	70
Kb	Kitchen middens over relatively impermeable soil material		Along streams and the coast	Very similar to adjacent soils but somewhat darker colored, calcareous and with shell fragments.			Slight	Moderate	Severe	Low	Slow permeability	50
Le	Los Osos clay, hilly	IVe5	Uplands	Gray, blocky, hard, slightly acid	Dark grayish brown clay, blocky, hard, neutral	Olive gray shale or clayey sandstone	Moderate	High	Severe	Moderate	Slow permeability	37
Lk	Los Osos clay loam, hilly, moderately eroded	IVe5	Uplands	Gray, blocky, hard, slightly acid	Dark grayish brown heavy clay loam, blocky, hard, neutral	Olive gray shale or clayey sandstone	Moderate	Moderate	Severe	Moderate	Well	27
Ln	Los Osos clay loam, steep, moderately eroded	VIe5	Uplands	Gray, blocky, hard, slightly acid	Dark grayish brown heavy clay loam, blocky, hard, neutral	Olive gray shale or clayey sandstone	Severe	Moderate	Severe	High	Well	14
M	Made land	VIII	——	This miscellaneous land type consists of areas of soil material used to fill swamps or other areas for construction purposes.			Slight	Variable	Variable	Low	Poor	2
Mb	Maymen fine sandy loam, hilly	VIe1	Uplands	Brown, granular, soft, medium acid	Very pale brown, fine sandy loam, granular, soft, medium acid	Pale yellow hard sandstone	Severe	Low	Severe	Low	Well	30
Mc	Maymen fine sandy loam, hilly, moderately eroded	VIe1	Uplands	Brown, granular, soft, medium acid	Very pale brown, fine sandy loam, granular, soft, medium acid	Pale yellow hard sandstone	Severe	Low	Severe	Low	Well	24
Md	Maymen stony fine sandy loam, hilly	VIIe1	Uplands	Brown, granular, soft, medium acid	Very pale brown stony fine sandy loam, granular, soft, acid	Pale yellow hard sandstone	Severe	Low	Severe	Low	Well	12
Me	Maymen stony soils, undifferentiated, steep and very steep	VIIIs1	Uplands	Brown, granular, soft, medium acid	Very pale brown stony fine sandy loam, granular, hard, acid	Pale yellow hard sandstone	Severe	Low	Severe	Low	Well	5
Mf	Milpitas fine sandy loam, deep, gently sloping and nearly level	IIIe3	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	65
Mh	Milpitas fine sandy loam, gently sloping, moderately eroded	IIIe3	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	33
Mj	Milpitas fine sandy loam, moderately steep	VIe3	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	38
Mk	Milpitas fine sandy loam, moderately steep, moderately eroded	VIe3	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	26
Ml	Milpitas fine sandy loam, moderately steep, severely eroded	VIIe1	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	15
Mm	Milpitas fine sandy loam, nearly level	IIIs3	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	50
Mn	Milpitas fine sandy loam, overwash, gently sloping and nearly level	IIIe3	Old terraces	Overwash of variable materials - 8 to 18 inches thick	Brown fine sandy loam, massive, hard, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Slight	Moderate	Severe	Low	Slow permeability	52
Mo	Milpitas fine sandy loam, rolling	IVe3	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown, variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	40
Mp	Milpitas fine sandy loam, rolling, moderately eroded	IVe3	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown, variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	28
Mq	Milpitas fine sandy loam, sloping	IVe3	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown, variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	43
Mr	Milpitas fine sandy loam, sloping, moderately eroded	IVe3	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown, variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	30
Ms	Milpitas fine sandy loam, sloping, severely eroded	VIe3	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown, variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	17
Mt	Milpitas fine sandy loam, steep	VIIe1	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown, variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	20
Mu	Milpitas fine sandy loam, steep, moderately eroded	VIIe1	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown, variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	14
Mv	Milpitas fine sandy loam, undulating	IIIe3	Old terraces	Brown, granular, soft, medium acid	Yellowish brown clay, prismatic, very hard, medium acid	Light yellowish brown, variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	45
Mw	Milpitas gravelly fine sandy loam, moderately steep and steep, moderately eroded	VIIe1	Old terraces	Brown, granular, soft, medium acid	Yellowish brown gravelly clay, prismatic, very hard, medium acid	Light yellowish brown, variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	12
Mx	Milpitas gravelly fine sandy loam, sloping, moderately eroded	IVe3	Old terraces	Brown, granular, soft, medium acid	Yellowish brown gravelly clay, prismatic, very hard, medium acid	Light yellowish brown, variable textured, massive, hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	21
My	Milpitas stony fine sandy, loam, moderately steep	VIIe1	Old terraces	Brown, granular, soft, medium acid	Yellowish brown stony clay, prismatic, very hard, medium acid	Light yellowish brown, variable textured, massive, hard, neutral	Moderate	Moderate	Severe	Low	Slow permeability	15
Mz	Milpitas stony fine sandy loam, sloping	VIs3	Old terraces	Brown, granular, soft, medium acid	Yellowish brown stony clay, prismatic, very hard, medium acid	Light yellowish brown, variable textured, massive, hard, neutral	Moderate	Moderate	Severe	Low	Slow permeability	17
MA	Milpitas stony fine sandy loam, steep	VIIs1	Old terraces	Brown, granular, soft, medium acid	Yellowish brown stony clay, prismatic, very hard, medium acid	Light yellowish brown, variable textured, massive, hard, neutral	Moderate	Moderate	Severe	Low	Slow permeability	8
MC	Mocho fine sandy loam, imperfectly drained, nearly level	IIw2	Edge of basins	Brown, granular, slightly hard, weakly calcareous	Pale brown sandy loam, mottled, massive, hard, calcareous, saline	Pale brown, variable coarse textured, mottled, massive, calcareous, salts	Slight	Low	Severe	Low	Poor	50
MD	Mocho fine sandy loam, nearly level	I	Alluvial fans and flood plains	Brown, granular, slightly hard, weakly calcareous	Brown sandy loam, massive, stratified, slightly hard, calcareous	Pale brown, variable coarse textures, massive, soft, calcareous	Slight	Low	Slight	Low	Well	100
ME	Mocho fine sandy loam over Clear Lake, nearly level	IIw2	Edge of basins	Brown, granular, slightly hard, weakly calcareous	Pale brown sandy loam, massive, stratified, slightly hard, calcareous	Black clay, coarse blocky, very hard, saline	Slight	High	Severe	Low	Poor	50
MG	Mocho loam, gently sloping	IIe1	Alluvial fans and flood plains	Brown, granular, slightly hard, weakly calcareous	Brown loam, massive, stratified, hard, calcareous	Pale brown, variable coarse textures, massive, soft, calcareous	Slight	Low	Slight	Low	Well	100
MH	Mocho loam, imperfectly drained, nearly level	IIw2	Edge of basins	Brown, granular, slightly hard, weekly calcareous	Pale brown loam, mottled, stratified, massive, hard, calcareous, saline	Pale brown, variable coarse textures, mottled, massive, calcareous, salts	Slight	Low	Severe	Low	Poor	50
MJ	Mocho loam, nearly level	I	Alluvial fans and flood plains	Brown, granular, slightly hard, weakly calcareous	Brown loam, massive, stratified, hard, calcareous	Pale brown, variable coarse textures, massive, soft, calcareous	Slight	Low	Slight	Low	Well	100
MK	Mocho loamy sand, imperfectly drained, nearly level	IIw2	Edge of basins	Brown, single grain loose, weakly calcareous	Grayish brown loamy sand, mottled, massive, hard, calcareous, saline	Light grayish brown, variable coarse textures, mottled, calcareous, salts	Slight	Low	Severe	Low	Poor	40
MN	Montezuma clay (adobe), gently sloping	IIe5	Old low terraces	Very dark gray, blocky, very hard, neutral	Dark gray clay, blocky, hard, weakly calcareous	Grayish brown clay, massive, hard, calcareous	Slight	High	Severe	Low	Slow permeability	46

TABLE OF SOIL CHARACTERISTICS AND INTERPRETATIONS OF THE GOLETA VALLEY

Soil Name	Cap Unit	Position	SOIL PROFILE: Surface Layer	Subsoil	Substratum or Parent Mtl.	Rocks and Stones	Shrink-Swell Potential	Septic Tank Filter Fields	Slippage	Drainage	Soil Index
Montezuma clay (adobe), nearly level	IIs5	Old low terraces	Very dark gray, blocky, very hard, neutral	Dark gray clay, blocky, hard, weakly calcareous	Grayish brown clay, massive, hard, calcareous	Slight	High	Severe	Low	Slow permeability	48
Montezuma clay (adobe), sloping	IIIe5	Old low terraces	Very dark gray, blocky, very hard, neutral	Dark gray clay, blocky, hard, weakly calcareous	Grayish brown clay, massive, hard, calcareous	Slight	High	Severe	Moderate	Slow permeability	41
Montezuma clay (adobe), sloping, moderately eroded	IIIe5	Old low terraces	Very dark gray, blocky, very hard, neutral	Dark gray clay, blocky, hard, weakly calcareous	Grayish brown clay, massive, hard, calcareous	Slight	High	Severe	Moderate	Slow permeability	29
Montezuma clay (adobe) undulating	IIe5	Old low terraces	Very dark gray, blocky, very hard, neutral	Dark gray clay, blocky, hard, weakly calcareous	Grayish brown clay, massive, hard, calcareous	Slight	High	Severe	Low	Slow permeability	43
Nacimiento clay, hilly	IVe5	Uplands	Dark grayish brown, blocky, hard, calcareous	Light olive gray clay, blocky, hard, calcareous	Light olive gray, soft, calcareous shale	Moderate	High	Severe	Moderate	Slow permeability	39
Nacimiento clay, hilly, moderately eroded	IVe5	Uplands	Dark grayish brown, blocky, hard, calcareous	Light olive gray clay, blocky, hard, calcareous	Light olive gray, soft, calcareous shale	Moderate	High	Severe	Moderate	Slow permeability	28
Nacimiento clay, sloping	IIIe5	Uplands	Dark grayish brown, blocky, hard, calcareous	Light olive gray clay, blocky, hard, calcareous	Light olive gray, soft, calcareous shale	Moderate	High	Severe	Moderate	Slow permeability	45
Nacimiento clay, steep	VIe5	Uplands	Dark grayish brown, blocky, hard, calcareous	Light olive gray clay, blocky, hard, calcareous	Light olive gray, soft, calcareous shale	Moderate	High	Severe	High	Slow permeability	21
Nacimiento clay, steep, moderately eroded	VIe5	Uplands	Dark grayish brown, blocky, hard, calcareous	Light olive gray clay, blocky, hard, calcareous	Light olive gray, soft, calcareous shale	Moderate	High	Severe	High	Slow permeability	13
Nacimiento clay, very steep	VIIe5	Uplands	Dark grayish brown, blocky, hard, calcareous	Light olive gray clay, blocky, hard, calcareous	Light olive gray, soft, calcareous shale	Moderate	High	Severe	High	Slow permeability	11
Nacimiento clay, very steep, moderately eroded	VIIe5	Uplands	Dark grayish brown, blocky, hard, calcareous	Light olive gray clay, blocky, hard, calcareous	Light olive gray, soft, calcareous shale	Moderate	High	Severe	High	Slow permeability	7
Nacimiento clay loam, hilly	IVe5	Uplands	Dark grayish brown, blocky, hard, calcareous	Light olive gray clay loam, blocky, hard, calcareous	Light olive gray, slightly hard, clayey sandstone	Severe	Moderate	Severe	Moderate	Well	38
Nacimiento clay loam, steep	VIe5	Uplands	Dark grayish brown, blocky, hard, calcareous	Light olive gray clay loam, blocky, hard, calcareous	Light olive gray, slightly hard, clayey sandstone	Severe	Moderate	Severe	High	Well	20
Nacimiento stony soils, undifferentiated, very steep	VIIe1	Uplands	Dark grayish brown, blocky, hard, calcareous	Light olive gray stony clay, blocky, hard, calcareous	Light olive gray, massive, stony, calcareous shale	Severe	Moderate	Severe	High	Well	10
Rough broken and stony land, Maymen soil material	VIIIs1	Uplands	This miscellaneous land type consists of sandstone and shale outcrops with some very shallow Maymen soils.			Severe	Low	Severe	Low	Well	5
Rough broken and stony land, Santa Lucia soil material	VIIIs1	Uplands	This miscellaneous land type consists of shale outcrops and some very shallow Santa Lucia soils.			Severe	Low	Severe	High	Well	3
San Andreas fine sandy loam, hilly	VIe1	Uplands	Grayish brown, granular, soft, medium acid	Light brownish gray loamy fine sand, single grain, medium acid	Light gray, soft sandstone	Slight	Low	Severe	Low	Well	45
San Andreas fine sandy loam, sloping, moderately eroded	IVe1	Uplands	Grayish brown, granular, soft, medium acid	Light brownish gray loamy fine sand, single grain, medium acid	Light gray, soft sandstone	Slight	Low	Moderate	Low	Well	36
San Andreas fine sandy loam, steep, moderately eroded	VIIe1	Uplands	Grayish brown, granular, soft, medium acid	Light brownish gray loamy fine sand, single grain, medium acid	Light gray, soft sandstone	Slight	Low	Severe	Low	Well	17
San Andreas loamy sand, hilly	VIe1	Uplands	Grayish brown, granular, soft, medium acid	Light brownish gray loamy sand, single grain, medium acid	Light gray, soft sandstone	Slight	Low	Moderate	Low	Well	36
San Andreas loamy sand, hilly, moderately eroded	VIe1	Uplands	Grayish brown, granular, soft, medium acid	Light brownish gray loamy sand, single grain, medium acid	Light gray, soft sandstone	Slight	Low	Moderate	Low	Well	25
San Andreas loamy sand, sloping	IVs4	Uplands	Grayish brown, granular, soft, medium acid	Light brownish gray loamy sand, single grain, medium acid	Light gray soft sandstone	Slight	Low	Slight	Low	Well	41
San Andreas loamy sand, steep	VIIe1	Uplands	Grayish brown, granular, soft, medium acid	Light brownish gray loamy sand, single grain, medium acid	Light gray soft sandstone	Slight	Low	Severe	Low	Well	19
San Andreas loamy sand, steep, moderately eroded	VIIe1	Uplands	Grayish brown, granular, soft, medium acid	Light brownish gray loamy sand, single grain, medium acid	Light gray soft sandstone	Slight	Low	Severe	Low	Well	13
San Andreas-Tierra fine sandy loams, hilly	VIe1	Uplands and old terraces	This is a complex of San Andreas and Tierra sandy loams. See individual descriptions of each soil. Limitations based on severest conditions.			Slight	Moderate	Severe	Low	Slow permeability	35
San Andreas-Tierra fine sandy loams, steep	VIIe1	Uplands and old terraces	This is a complex of San Andreas and Tierra sandy loams. See individual descriptions of each soil. Limitations based on severest conditions.			Slight	Moderate	Severe	Low	Slow permeability	15
Santa Lucia shaly clay loam, hilly	IVe1	Uplands	Dark gray, granular, hard, medium acid	Dark gray shaly clay loam, granular, hard, medium acid	Light gray, hard, massive shale	Severe	Moderate	Severe	Low	Well	26
Santa Lucia shaly clay loam, sloping	IIIe1	Uplands	Dark gray, granular, hard, medium acid	Dark gray shaly clay loam, granular, hard, medium acid	Light gray, hard, massive shale	Severe	Moderate	Severe	Low	Well	30
Santa Lucia shaly clay loam, steep	VIe1	Uplands	Dark gray, granular, hard, medium acid	Dark gray shaly clay loam, granular, hard, medium acid	Light gray, hard, massive shale	Severe	Moderate	Severe	Moderate	Well	14
Santa Lucia stony clay loam, hilly	VIs7	Uplands	Dark gray, granular, hard, medium acid	Dark gray stony clay loam, granular, hard, medium acid	Light gray, hard, massive shale	Severe	Moderate	Severe	Low	Well	15
Santa Lucia stony soils undifferentiated, steep and very steep	VIIIs1	Uplands	Dark gray, granular, hard, medium acid	Dark gray stony variable texture, hard, medium acid	Light gray, hard, massive shale	Severe	Moderate	Severe	Moderate	Well	5
Sespe clay, hilly	IVe5	Uplands	Brown, granular, hard, neutral	Dark brown clay, blocky, hard, calcareous	Light brownish gray, calcareous shale or clayey sandstone	Moderate	High	Severe	Moderate	Slow permeability	37
Sespe clay, hilly, moderately eroded	IVe5	Uplands	Brown, granular, hard, neutral	Dark brown clay, blocky, hard, calcareous	Light brownish gray, calcareous shale or clayey sandstone	Moderate	High	Severe	Moderate	Slow permeability	26
Sespe clay, steep	VIe5	Uplands	Brown, granular, hard, neutral	Dark brown clay, blocky, hard, calcareous	Light brownish gray, calcareous shale or clayey sandstone	Moderate	High	Severe	High	Slow permeability	20
Sespe clay loam, hilly	IVe5	Uplands	Brown, granular, hard, neutral	Dark brown heavy clay loam, blocky, hard, calcareous	Light brownish gray, calcareous shale or clayey sandstone	Moderate	Moderate	Severe	Moderate	Well	38
Sespe clay loam, hilly, moderately eroded	IVe5	Uplands	Brown, granular, hard, neutral	Dark brown heavy clay loam, blocky, hard, calcareous	Light brownish gray, calcareous shale or clayey sandstone	Moderate	Moderate	Severe	Moderate	Well	27
Sespe clay loam, sloping	IIIe5	Uplands	Brown, granular, hard, neutral	Dark brown heavy clay loam, blocky, hard, calcareous	Light brownish gray, calcareous shale or clayey sandstone	Moderate	Moderate	Severe	Moderate	Well	43
Sespe clay loam, steep	VIe5	Uplands	Brown, granular, hard, neutral	Dark brown heavy clay loam, blocky, hard, calcareous	Light brownish gray, calcareous shale or clayey sandstone	Moderate	Moderate	Severe	High	Well	20
Sespe clay loam, steep, moderately eroded	VIe5	Uplands	Brown, granular, hard, neutral	Dark brown heavy clay loam, blocky, hard, calcareous	Light brownish gray, calcareous shale or clayeye sandstone	Moderate	Moderate	Severe	High	Well	14
Sespe nonstony soils, undifferentiated, very steep	VIIe5	Uplands	Brown, granular, hard, neutral	Dark brown variable texture, blocky, hard, calcareous	Light brownish gray, calcareous shale or clayey sandstone	Severe	Moderate	Severe	High	Well	8
Sespe stony soils, undifferentiated, very steep	VIIIs1	Uplands	Brown, granular, hard, neutral	Dark brown, stony, variable texture, blocky, hard, calcareous	Light brownish gray, calcareous shale or clayey sandstone	Severe	Moderate	Severe	High	Well	5
Sorrento fine sandy loam, gently sloping	IIe1	Alluvial fans and flood plains	Dark grayish brown, granular, slightly hard, neutral	Pale brown fine sandy loam, massive, soft, calcareous	Pale brown, fine sand, loam, stratified, soft, calcareous	Slight	Low	Slight	Low	Well	95

Map Sym.	Soil Name	Cap Unit	Position	SOIL PROFILE: Surface Layer	Subsoil	Substratum or Parent Mtl.	Rocks and Stones	Septic Tank Filter Fields	Shrink-Swell Potential	Slippage	Drainage	Soil Index
SL	Sorrento fine sandy loam, imperfectly drained, nearly level	IIw2	Edge of basins	Dark grayish brown, granular, slightly hard, neutral	Pale brown fine sandy loam, mottled, massive, soft, calcareous	Pale brown, variable coarse textures, mottled, massive, calcareous	Slight	Low	Severe	Low	Poor	50
SM	Sorrento fine sandy loam, nearly level	I	Alluvial fans and flood plains	Dark grayish brown, granular, slightly hard, neutral	Pale brown fine sandy loam, massive, soft, calcareous	Pale brown, fine sandy loam, stratified, soft, calcareous	Slight	Low	Slight	Low	Well	100
SN	Sorrento fine sandy loam over Clear Lake, nearly level	IIw2	Edge of basins	Dark grayish brown, granular, slightly hard, neutral	Pale brown fine sandy loam, massive, soft, calcareous	Black clay, coarse blocky, very hard, saline	Slight	High	Severe	Low	Poor	50
SQ	Sorrento loam, gently sloping	IIe1	Alluvial fans and flood plains	Dark grayish brown, granular, slightly hard, neutral	Pale brown loam, massive, soft, calcareous	Pale brown loam, stratified, soft, calcareous	Slight	Low	Slight	Low	Well	95
SR	Sorrento loam, imperfectly drained, nearly level	IIw2	Edge of basins	Dark grayish brown, granular, slightly hard, neutral	Pale brown loam, mottled, massive, soft, calcareous	Pale brown laom, mottled, massive, soft, calcareous	Slight	Low	Severe	Low	Poor	50
SS	Sorrento loam, nearly level	I	Alluvial fans and flood plains	Dark grayish brown, granular, slightly hard, neutral	Pale brown loam, massive, soft, calcareous	Pale brown loam, stratified, soft, calcareous	Slight	Low	Slight	Low	Well	100
ST	Sorrento loam, sloping	IIIe1	Alluvial fans and flood plains	Dark grayish brown, granular, slightly hard, neutral	Pale brown loam, massive, soft, calcareous	Pale brown loam, stratified, soft, calcareous	Slight	Low	Moderate	Low	Well	85
SU	Sorrento loamy sand, gently sloping	IIIs4	Alluvial fans and flood plains	Dark grayish brown, granular, slightly hard, neutral	Pale brown stratified sands, loose, calcareous	Pale brown stratified sands, loose, calcareous	Slight	Low	Slight	Low	Well	76
SV	Sorrento loamy sand, nearly level	IIIs4	Alluvial fans and flood plains	Dark grayish brown, granular, slightly hard, neutral	Pale brown stratified sands, loose, calcareous	Pale brown stratified sands, loose, calcareous	Slight	Low	Slight	Low	Well	80
Tk	Terrace breaks	VIIe1	Terrace escarpments	This miscellaneous land type consists of steep terrace escarpments. The soil has some characteristics resembling the soils on the terraces it is associated with.			Slight	Moderate	Severe	Low	Well	5
Tl	Tidal marsh	VIIIw4	Basins and lagoons	This miscellaneous land type consists of very wet, saline swamp land.			Slight	Variable	Severe	Low	Poor	2
Tm	Tierra fine sandy loam, hilly, moderately eroded	VIe3	Old terraces	Dark gray, granular, hard, strongly acid	Gray clay, blocky, very hard, medium acid	Grayish brown, variable textured, massive, very hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	21
To	Tierra fine sandy loam, sloping, moderately eroded	IVe3	Old terraces	Dark gray, granular, hard, strongly acid	Gray clay, blocky, very hard, medium acid	Grayish brown, variable textured, massive, very hard, neutral	Slight	Moderate	Severe	Low	Slow permeability	24
Wa	Watsonville fine sandy loam, gently sloping	IIIe3	Low terraces	Dark gray, granular, hard, medium acid	Dark gray clay, prismatic, very hard, medium acid	Gray sandy clay loam, mottled, massive, hard, medium acid	Slight	Moderate	Severe	Low	Slow permeability	38
Wb	Watsonville fine sandy loam, gently sloping, moderately eroded	IIIe3	Low terraces	Dark gray, granular, hard, medium acid	Dark gray clay, prismatic, very hard, medium acid	Gray sandy clay loam, mottled, massive, hard, medium acid	Slight	Moderate	Severe	Low	Slow permeability	27
Wc	Watsonville fine sandy loam, moderately steep	VIe3	Low terraces	Dark gray, granular, hard, medium acid	Dark gray clay, prismatic, very hard, medium acid	Gray sandy clay loam, mottled, massive, hard, medium acid	Slight	Moderate	Severe	Low	Slow permeability	30
Wd	Watsonville fine sandy loam, moderately steep, moderately eroded	VIe3	Low terraces	Dark gray, granular, hard, medium acid	Dark gray clay, prismatic, very hard, medium acid	Gray sandy clay loam, mottled, massive, hard, medium acid	Slight	Moderate	Severe	Low	Slow permeability	18
We	Watsonville fine sandy loam, nearly level	IIIs3	Low terraces	Dark gray, granular, hard, medium acid	Dark gray clay, prismatic, very hard, medium acid	Gray sandy clay loam, mottled, massive, hard, medium acid	Slight	Moderate	Severe	Low	Slow permeability	40
Wf	Watsonville fine sandy loam, sloping	IVe3	Low terraces	Dark gray, granular, hard, medium acid	Dark gray clay, prismatic, very hard, medium acid	Gray sandy clay loam, mottled, massive, hard, medium acid	Slight	Moderate	Severe	Low	Slow permeability	34
Wg	Watsonville fine sandy loam, sloping, moderately eroded	IVe3	Low terraces	Dark gray, granular, hard, medium acid	Dark gray clay, prismatic, very hard, medium acid	Gray sandy clay loam, mottled, massive, hard, medium acid	Slight	Moderate	Severe	Low	Slow permeability	24
Wm	Watsonville loam, nearly level	IIIs3	Low terraces	Dark gray, granular, hard, medium acid	Dark gray clay, prismatic, very hard, medium acid	Gray sandy clay loam, mottled, massive, hard, medium acid	Slight	Moderate	Severe	Low	Slow permeability	40
Wo	Watsonville loam, sloping, moderately eroded	IVe3	Low terraces	Dark gray, granular, hard, medium acid	Dark gray clay, prismatic, very hard, medium acid	Gray sandy clay loam, mottled, massive, hard, medium acid	Slight	Moderate	Severe	Low	Slow permeability	24
Ya	Yolo fine sandy loam, gently sloping	IIe1	Alluvial fans and flood plains	Dark gray, granular, hard, neutral	Dark grayish brown fine sandy loam, massive, hard, neutral	Dark grayish brown fine sandy loam, stratified, hard, neutral	Slight	Low	Slight	Low	Well	95
Yb	Yolo fine sandy loam, nearly level	I	Alluvial fans and flood plains	Dark gray, granular, hard, neutral	Dark grayish brown fine sandy loam, massive, hard, neutral	Dark grayish brown fine sandy loam, stratified, hard, neutral	Slight	Low	Slight	Low	Well	100
Ye	Yolo loam, gently sloping	IIe1	Alluvial fans and flood plains	Dark gray, granular, hard, neutral	Dark grayish brown loam, massive, hard, neutral	Dark grayish brown loam, stratified, hard, neutral	Slight	Low	Slight	Low	Well	95
Yf	Yolo loam, imperfectly drained, nearly level	IIw2	Edge of basins	Dark gray, granular, hard, neutral	Dark grayish brown loam, mottled, massive, hard, neutral	Dark grayish brown loam, mottled, stratified, hard, neutral	Slight	Low	Severe	Low	Poor	50
Yg	Yolo loam, nearly level	I	Alluvial fans and flood plains	Dark gray, granular, hard, neutral	Dark grayish brown loam, massive, hard, neutral	Dark grayish brown loam, stratified, hard, neutral	Slight	Low	Slight	Low	Well	100
Yh	Yolo sandy loam, gently sloping	IIe1	Alluvial fans and flood plains	Dark gray, granular, hard, neutral	Dark grayish brown sandy loam, massive, hard, neutral	Dark grayish brown sandy loam, stratified, hard, neutral	Slight	Low	Slight	Low	Well	90
Yk	Yolo sandy loam, nearly level	I	Alluvial fans and flood plains	Dark gray, granular, hard, neutral	Dark grayish brown sandy loam, massive, hard, neutral	Dark grayish brown sandy loam, stratified, hard, neutral	Slight	Low	Slight	Low	Well	95
Za	Zaca clay, hilly	IVe5	Uplands	Very dark gray, blocky, hard, calcareous	Dark gray clay, blocky, hard, calcareous	Pale yellow massive calcareous shale	Moderate	High	Severe	Moderate	Slow permeability	39
Zb	Zaca clay, hilly, moderately eroded	IVe5	Uplands	Very dark gray, blocky, hard, calcareous	Dark gray clay, blocky, hard, calcareous	Pale yellow massive calcareous shale	Severe	High	Severe	Moderate	Slow permeability	28
Zc	Zaca clay, sloping	IIIe5	Uplands	Very dark gray, blocky, hard, calcareous	Dark gray clay, blocky, hard, calcareous	Pale yellow massive, calcareous shale	Moderate	High	Severe	Moderate	Slow permeability	45
Zd	Zaca clay, steep	VIe5	Uplands	Very dark gray, blocky, hard, calcareous	Dark gray glay, blocky, hard, calcareous	Pale yellow massive calcareous shale	Moderate	High	Severe	High	Slow permeability	21
Ze	Zaca clay, steep, moderately eroded	VIe5	Uplands	Very dark gray, blocky, hard, calcareous	Dark gray clay, blocky, hard, calcareous	Pale yellow massive calcareous shale	Severe	High	Severe	High	Slow permeability	15
Zg	Zaca clay loam, hilly	IVe5	Uplands	Very dark gray, blocky, hard, calcareous	Dark gray clay, blocky, hard, calcareous	Pale yellow massive calcareous shale	Severe	Moderate	Severe	Moderate	Well	38
Zh	Zaca clay loam, sloping, moderately eroded	IIIe5	Uplands	Very dark gray, blocky, hard, calcareous	Dark gray clay, blocky, hard, calcareous	Pale yellow massive calcareous shale	Severe	Moderate	Severe	Moderate	Well	35
Zk	Zaca clay loam, steep	VIe5	Uplands	Very dark gray, blocky, hard, calcareous	Dark gray clay, blocky, hard, calcareous	Pale yellow massive calcareous shale	Severe	Moderate	Severe	High	Well	20
Zl	Zaca nonstony soils, undifferentiated, very steep	VIIe5	Uplands	Very dark gray, blocky, hard, calcareous	Dark gray, variable textures, blocky, hard, calcareous	Pale yellow massive calcareous shale	Severe	Moderate	Severe	High	Well	10

APPENDIX 7

COSTS FIRE CONTROL FACILITIES
GOLETA FLOOD CONTROL PROJECT
U.S. Forest Service Figures

	INITIAL	ANNUAL	TOTAL
FIRE PREVENTION TECHNICIAN			
Truck	2,000		2,000
Pump and Equipment	2,000		2,000
Radio	500		500
Salary		6,000	6,000
Mileage		1,500	1,500
TOTAL	4,500	7,500	12,000
TANKER STATION			
Station (Dos Pueblos):	20,000		20,000
8 man barracks	40,000		40,000
Foreman's house	18,000		18,000
Fire Prevention Technician's house	18,000		18,000
Truck (500 gallon, all wheel-drive):	20,000		20,000
Radio (truck)	500		500
Radio (station)	500		500
Full time foreman		6,000	6,000
Full time assistant foreman (TTO)		5,500	5,500
Seasonal TTO		3,000	3,000
Seasonal crewman		3,000	3,000
Seasonal crewman		2,800	2,800
Annual operating and maintenance		500	500
TOTAL	117,000	20,300	137,800
Air tankers:			
2 air tankers at Goleta Airport		10,000	10,000
Helicopter			
1 helicopter and crew		5,000	5,000
Pre-attack block	10,000	500	10,500
Water catchments:			
(15) 10,000 gallon	90,000	300	90,300
Concrete tanks	---	---	---
Lookout coverage:			
La Cumbre		600	600
Santa Ynez		600	600
TOTAL		1,200	1,200

FUELBREAKS

NAME	MILES	ACRES	TRACTOR ACRES	COST P/A	HAND ACRES	INITIAL COST	ANNUAL COST
Glen Annie	3.6	210	150	2	60	39,000	2,500
Haney Tract	3.7	149	149	1	--	11,200	1,800
San Pedro	3.7	150	110	3	40	49,000	1,800
Las Varas	2.6	106	76	3	30	27,200	1,300
San Jose	1.8	75	75	2	--	7,500	1,000
Painted Cave	2.0	85	75	1	10	8,100	1,000
Painted Cave to Hgw. 154	.8	34	34	3	--	6,800	400
Windy Gap Spur	.8	34	34	2	--	3,400	400
Barger Canyon	3.1	132	100	3	32	42,800	1,600
Camino Cielo-San Marcos	1.3	55	---	-	55	22,000	1,100
TOTAL	23.4	1,030	803	20	227	217,000	12,900

FUELBREAK ACCESS		COST P/M		
Glen Annie	3.6	4,000	14,400	360
San Pedro	3.7	4,000	14,500	370
Las Varas	2.0	3,000	6,000	200
San Jose	1.8	2,000	3,600	160
Painted Cave	1.0	1,000	1,000	100
Painted Cave to Hgw. 154	.8	3,000	2,400	80
Windy Gap Spur	.8	1,000	800	80
Barger Canyon	3.1	4,000	12,400	300
TOTAL	16.8	22,000	55,100	1,650

Fuelbreak costs based on following:

1. Tractor clearing cost per acre
   1 = $ 75.00 p/a
   2 = 100.00 p/a
   3 = 200.00 p/a

The code is listed for each fuelbreak under cost per acre.

2. Hand clearing costs are based on $400.00 per acre. If project is done piece-meal then these costs will rise about $200.00 per acre because of inexperienced labor.

3. Annual maintenance cost based on $12.00 per acre for spray - these costs will drop after 3 years.

Hazard Reduction:

50' strip each side of roadway

$600.00 use as basis for initial clearing using chipper for disposal

$ 20.00 use as annual cost for maintenance first 3 years based on cost per acre for hand spray work close to roadways. Cost after first three years would drop to fuelbreak costs: $3.00 per acre per year based on chemical treatment once every 5-7 years.

ROAD	MILES	ACRES	INITIAL COST	ANNUAL MTC. COST	COST TOTAL
San Marcos	6.0	73	43,800	1,460	1,460
Old San Marcos	3.5	35	21,000	700	700
Painted Cave	3.0	37	22,200	740	740
W. Camino Cielo	4.5	55	33,000	1,100	1,100
Edison Jeepway San Marcos East	2.5	30	18,000	600	600
Edison Jeepway Old San Marcos West	11.5	140	84,000	2,800	2,800

APPENDIX 8

PROGRAM AND PROJECT AUTHORITY

Program authority for the Project by the Soil Conservation District is set forth in Division 9 of the California State Public Resources Code (1965 Statutes) as follows:

Sec. 9250: The Board of Directors of a (Soil Conservation) District shall manage and conduct the business and affairs of the District.

Sec. 9251: The Directors may accept gifts and grants of money from any source whatsoever to carry out the purposes of the District.

Sec. 9261: The Directors shall develop district-wide comprehensive plans for the soil and water conservation...

The State of California through the State Soil Conservation Commission participated in accordance with Division 9 of the California State Public Resources Code as follows:

Sec. 9063.1: From such money as may be appropriated therefore the Commission may make grants to (soil conservation) Districts in carrying out any work they are authorized to undertake.

The appropriate empowering authority for coordinated action by the Santa Barbara Flood Control and Water Conservation District was established through a "Joint Exercise of Powers Agreement". A copy of this form of agreement is included in Appendix E. Provisions calling for a joint coordinated course of action rinanced by cooperating parties are authorized for participation under Title I, Division 7, Chapter 5 of the Government Code of the State of California as follows:

Joint Exercise of Powers (Stats. 1949), Title 1, Division 7, Chapter 5, Government Code

Sec. 6502: If authorized by their legislative or other governing bodies, two or more public agencies by agreement may jointly exercise any power common to the contracting parties--(Stats. 1949)

Sec. 6503: The agreements shall state the purpose of the agreement or the power exercised. They shall provide for the method by which the purpose will be accomplished or the manner in which the power will be exercised. (Stats. 1949)

Sec. 6504: The parties to the agreement may provide that (a) contributions from the treasuries may be made for the purpose set forth in the agreement, (b) payments of public funds may be made to defray the cost of such purpose, (c) advances of public funds may be made for the purpose set forth in the agreement, such advances to be repaid as provided in said agreement, or (d) personnel, equipment or property of one or more of the parties to the agreement may be used in lieu of other contributions or advances. The funds may be paid to and disbursed by the agency or entity agreed upon. (Stats. 1963)

Sec. 6505: The agreement shall provide for strict accountability of all funds and report of all receipts and disbursements. (Stats. 1949)

Sec. 6506: The agency or entity provided by the agreement to administer or execute the agreement may be one or more of the parties to the agreement or a commission or board constituted pursuant to the agreement or a person, firm or corporation designated in the agreement. One or more of the parties may agree to provide all or a portion of the services to the other parties in the manner provided in the agreement. The parties may provide for the mutual exchange of services without payment of any consideration other than such services. (Stats. 1963)

Sec. 6507: For the purposes of this article, the agency is a public entity separate from the parties to the agreement.

Sec. 6508: The agency shall possess the common power specified in the agreement and may exercise it in the manner or according to the method provided in the agreement. If the agency is not one or more of the parties to the agreement but is a public entity, commission or board constituted pursuant to the agreement and such agency is authorized, in its own name, to do any or all of the following: to make and enter contracts, or to employ agents and employees, or to acquire, construct, manage, maintain or operate any buildings, works or improvements, or to acquire, hold or dispose of property or to incur debts, liabilities or obligations which do not constitute the debt, liability or obligation of any of the parties to the agreement, said agency shall have the power to sue and be sued in its own name. (Stats. 1963)

APPENDIX 9

JOINT EXERCISE OF POWERS AGREEMENT BETWEEN THE SANTA BARBARA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT AND THE SANTA BARBARA SOIL CONSERVATION DISTRICT

THIS AGREEMENT, made and entered into this 13th day of February, 1962, by and between the SANTA BARBARA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT, a flood control district created by Statutes of 1955, Chapter 1057 of the State of California, hereinafter referred to for convenience as County, and the SANTA BARBARA SOIL CONSERVATION DISTRICT, hereinafter referred to as District.

WITNESSETH THAT:

WHEREAS, District has executed an agreement with the State of California, acting by and through the State Soil Conservation Commission, hereinafter called the State, pursuant to the provisions of the California Public Resources Code 6816.1, whereby the State grants to the District the sum of Twenty-Five Hundred Dollars ($2,500) to be applied towards the cost of doing certain specific conservation work set forth in detail therein; and

WHEREAS, the District and the County desire to enter into a joint exercise of powers agreement for certain purposes hereinafter set forth,

NOW, THEREFORE, IT IS HEREBY AGREED as follows:

1. That for the purposes hereinafter mentioned, District hereby agrees to pay to County the sum of Twenty-Five Hundred Dollars ($2,500).

2. The purpose of this agreement is to assist in developing a comprehensive soil and water conservation plan for the Goleta Valley Watershed.

3. The methods by which the purpose will be accomplished will be to make studies and investigations to acquire all available information on reservoir sites, channel improvements, irrigation, drainage, soil surveys, crop surveys, temperature, precipitation, flood control and other related data.

4. There shall be a Project Chairman and a Project Coordinating Committee. The Project Coordinating Committee shall be composed of representatives of participating agencies, said representatives being duly appointed by the Project Chairman. The said Project Chairman shall be a Director duly nominated and appointed by the said Santa Barbara Soil Conservation District.

5. The funds shall be paid to and disbursed by County pursuant to the terms and conditions herein contained subject to the review and approval of the Project Chairman. There shall be strict accountability of all funds and report of all receipts and disbursements by the County, which is the agency to administer and execute this agreement. After completion of the purpose of this agreement, any surplus money on hand contributed by the parties hereto shall be returned in proportion to the contributions made by each.

6. To the extent that the improvements established with the said funds are reasonably necessary to effect the purpose of the project, the County will provide for maintenance so that the project will be at all times useable and operative.

7. The County shall prepare and submit to the District in duplicate the following reports:

A. A monthly fiscal statement showing expenditures and status of funds. The Project Chairman shall verify the said statement in submitting a monthly progress report to the District.

B. A report showing annual accounting of project expenditures, submitted within 60 days after the close of each fiscal year until all District funds are expended.

C. A report showing total final project expenditures, submitted within 60 days after all District funds are expended.

D. A report on work performed or accomplished and such related information on evaluation and maintenance as may be essential to an appraisal of the completed project submitted on completion of the project.

8. The County shall make available for inspection by the District at all reasonable times all books, records and documents pertinent to the project. The District shall at all reasonable times have access to the project and the whole thereof for the purpose of ascertaining the progress of the work and the accomplishment of the project.

9. The parties hereto agree that the County, and agents or employees of the County in performance of this contract, shall act in an independent capacity and not as officers or employees of the Santa Barbara Soil Conservation District.

10. The County hereby accepts said grant subject to the provisions of this agreement and agrees to expeditiously proceed with, jointly with other participating agencies, the conservation work as outlined and stipulated as follows:

A. Accumulate an inventory of all available information on reservoir sites, channel improvements, irrigation, drainage, soil surveys, crop surveys, temperature, precipitation, flood control, and other data related to development of a comprehensive soil and water conservation plan for the Goleta Valley Watershed area.

B. Secure additional information the inventory shows is needed in order to develop a comprehensive soil and water conservation plan for the said Goleta Valley Watershed area.

C. Submit a report in duplicate at the conclusion of Item A above showing the additional information needed to be secured under Item B above. At the conclusion of this first year phase of this project, submit a summary report in accordance with Paragraph 7(C) of this agreement.

D. Upon payment into the County Treasury by District of its share of funds for said project, and notification of the County, County will deposit the sum as indicated in Paragraph 1 hereof.

IN WITNESS WHEREOF, the parties hereto have hereunto set their hands the day and year first above written.

ATTEST:

By Peter Cavaletto
Secretary

SANTA BARBARA SOIL CONSERVATION DISTRICT

By Ali Mauracher
Chairman, Board of Directors

ATTEST:

By J.E. Lewis (Seal)
County Clerk

SANTA BARBARA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

By Daniel G. Grant
Chairman, Board of Directors